Chemical & Process Engineering

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Topics of the Month

Sulphur recovery from fuels

AT a recent conference organised by the Institute of Fuel in London, 13 papers were presented by scientific authorities of wide experience in the removal and recovery of sulphur in specific industrial processes. The discussions ranged over a wide field. One of the conclusions reached was that the main source of indigenous sulphur is that contained in our coal. This amounts to over 3 million tons p.a. and we now recover only 5 to 6% of it. Sulphur in petroleum represents another 600,000 tons and we are aiming to recover only 5% of that. The recovery of a higher proportion is essential for reasons of national economy, since we now import 75% of our sulphur requirements. Action is made more pressing by the deleterious effects of sulphur in industrial processes, particularly metallurgy and glass, and by injury to buildings, plants and human health by oxides of sulphur emitted to the atmosphere.

Sulphur in the coal seam is rising slowly and in fuel oil has risen markedly, and every effort must be made to find means of reducing sulphur content after mining the coal or before marketing the oil in such a manner that recovery in usable form is possible. The industrial value of a lower sulphur content of fuel to industry is not clearly defined and some definition should be attempted in order to assess the possible value of removal processes, since these are likely to be expensive. Coal of high caking power and low sulphur content may have to be reserved, or medium-sulphur-content coal cleaned, to provide low-sulphur coal to the iron and steel industries. Unless fuel oils can be reduced in sulphur content, this will impose some limitation of usage in processes where sulphur is a difficult factor.

The gas industry now recovers 40% of the sulphur of its coal by effective means. A number of large-scale flow methods are now available, but there are doubts as to their suitability for British conditions and as to their operating costs. They will remove 70 to 80% of the hydrogen sulphide from gas, but the real consideration is whether any process can be worked in a given environment so as to produce by-product sulphuric acid or sulphur on an economic basis. The cleaning of coke-oven gas not now cleaned could add 60% to the gas industry's contribution to indigenous sulphur.

A further conclusion endorsed by the conference was that combustion gases from very large power stations are a potentially large source of sulphur of which effective recovery is more than desirable, as well as its removal from the atmosphere.

It is regrettable that no new indigenous source of sulphur has been disclosed by the conference, but the papers have focused interest so strongly on existing methods of recovery that this surely must give added impetus to further industrial action.

Britain should seek new petroleum processes

'LET us carry out research and invent our own processes.' This possible approach to the further development of the petroleum industry in Britain was suggested by Lt.-Col. S. J. M. Auld, president of the Institute of Petroleum, at the annual luncheon of the Council of British Manufacturers of Petroleum Equipment in London recently. He pointed out that nationally and individually the Americans have encouraged and partaken in the development of the petroleum industry in the U.K., but there is one thing they cannot give—their vested experience. On the process side, for example, major action emanates from the U.S. Even the few great processes originated elsewhere have been and could only have been turned into realities in America. It is natural, for example, because of their 600 long-established refineries to the 60 in Europe, that these processes should have originated or have been designed and engineered in the United States; also that the manufacturing of the plant and equipment should be primarily American and that the 'pickings' should be American.

Col. Auld pointed out that to carry out the necessary research as suggested would be a long and costly business. However, whilst a search for new processes was going on at the universities or schools of technology, quicker and possibly equally far-reaching results might be obtained by the organisation of groups of manufacturers of petroleum equipment, capable of taking on complete jobs and so gaining experience in the kind of process work which inevitably leads to improvement and invention.

The chairman of the C.B.M.P.E., Mr. D. Wilson, said that the subject of research was engaging the attention of the Council as a major part of its future policy. He also referred to an urgent need to promote a more intensive interest in petroleum technology in the universities and elsewhere.

Plastics for elevated-temperature use

THE growing need for plastics for use at elevated temperatures is a challenge to scientists. No 'common' or readily available plastic will stand up under many and varied conditions at temperatures in excess of 200°C. At present, there is no material in this class that will function continuously at 500°C. and retain its properties. The nearest approach to be found is the fluoro polymer *Teflon*. However, E. L. Kropa, R. G. Heiligmann and E. E. McSweeney, of Battelle Institute, Columbus, Ohio, believe that the development of plastic materials to withstand still higher temperatures is possible. Their discussion of the basis for such a belief formed a section of their paper, 'Current United States Plastic Developments,' which was presented recently before the 27th International Congress of Industrial Chemistry, at Brussels.

They pointed out that the absence of hydrogen is a characteristic of such heat-resistant materials as minerals, glasses, diamonds and completely fluorinated polymers. The authors suggest that high thermal stability in plastics may also be related to an absence of hydrogen rather than to the presence of so-called heat-resistant elements. Furthermore, the development of plastics with better thermal properties may call for the invention of an entirely new structure that will make more efficient use of the strengths in the bonds linking the atoms than is made by conventional polymer chains.

Kropa *et al.* suggest that information from the fields of glass, metals and polymers is needed for the development of high-temperature plastics. Fundamental studies by a ceramist, metallurgist and polymeric chemist on the problem of thermal stability in their fields might lead to a new approach in the development of more thermally stable polymeric materials.

New scope for chemical engineering and technology in Scotland

IT would be surprising if Scotland—a traditional home of engineering—had not produced a number of engineers and scientists who have distinguished themselves in the chemical and allied fields. But there has been for some time a consciousness that Scotland as a community is lagging in the development of chemical engineering techniques. To some extent this may be due to lack of a focal point for further development, for there has hitherto been no organised body of chemical engineers there as such. However, the usefulness of chemical engineering in the development of Scotland's new industries, and perhaps most of all the emergence of Grangemouth as a centre of chemical engineering industry, made the ultimate formation of such a group essential and inevitable. There are something like 120 members of the Institution of Chemical Engineers resident in Scotland, and of these about 60 attended a meeting some time ago to see what could be done about setting up a Scottish Group. A Group has now been formed, officers elected and meetings arranged. The formation of this Group, of which further particulars are given on another page, augurs well for the future of chemical engineering in Scotland.

Another welcome item of news from Scotland is that the establishment of a new Chair of Chemical Technology, and of a new degree in place of the present B.Sc. in Technical Chemistry, is included in the University of Edinburgh's plans, which involve closer integration of the university's work with that of the Heriot-Watt College, Edinburgh. The university has its own department of technical chemistry; the college has provided education in technical chemistry and chemical engineering. The new department will be accommodated in laboratories to be built at the Heriot-Watt College. Initially the new degree will be given only in the Department of Chemical Technology, but there will be provision for awarding it in other fields later.

Silicone manufacture comes to Britain

BRITAIN'S first full-scale silicone plant, described in November, comes into production eight years after Albright & Wilson first accepted the sales agency for Dow Corning silicones, and some 50 years after Prof. F. S. Kipping, of the University of Nottingham, began his extensive work on the organic chemistry of silicon. Kipping's work laid the foundation for much of the present-day progress in silicones, but, despite this, silicones remained only fascinating laboratory curiosities—of considerable scientific interest but of little practical value. Even Kipping took this view and in his address to the Royal Society in 1937 stated that 'the prospect of any immediate and important advance in this section of chemistry does not seem to be very hopeful.'

The commercial production of silicones as we now know them arose from the search for heat-stable resins to be used in electrical insulation with glass fibre. The Corning Glass Works of America initiated these researches in 1932 under the direction of Dr. Sullivan and with J. F. Hyde as chief investigator. Hyde studied Kipping's work and was led to look further into those resinous by-products which had so

Comical Engineering Terms

"SOLVENT EXTRACTION"

frequently hampered Kipping's experiments. This line of research proved so promising that the assistance of the Dow Chemical Co. was sought towards the end of the 1930s in order to examine the possibilities of commercial production. At about the same time General Electric in the United States also became interested and E. G. Rochow began his work there.

Thus at the opening of the 1939-45 war the commercial manufacture of silicones was in sight and was spurred on by the entry of the United States into the war. The first practicable silicone, an ignition sealing compound for aircraft engines, was followed very shortly by a series of resins and fluids. In 1943 Dow Corning Corporation was formed to manufacture silicones and since then interest and activity in the United States and the rest of the world have rapidly increased.

Fifty years of vanadium

AN important event in the industrial history of vanadium occurred just 50 years ago when Riza Patron discovered the extensive rich deposits of ore at a point 16,000 ft. in the Peruvian Andes. This ore, containing 40% of the sulphide VS_3 was named Patronite after him. But vanadium history began when Manuel Del Rio discovered a new element which he called ' erythronium ' because of its red-coloured salts, the element being ignored as probable chromium. Wöhler missed the re-discovery and so it was left to Sefström of Sweden to find vanadium in an iron ore and to give it a classical name after Vanadis, the Scandinavian goddess. To add to the curious history of this attractive element one of Sefström's students spilled the first sample of dissolved vanadium which Sefström had so laboriously extracted. (History does not record what Sefström said to this clumsy pupil!) Later, in the 1880s, Sir Henry Roscoe and Sir Edward Thorpe made a thorough study of vanadium reactions and compounds, and prepared a sample pure enough when compared with those of Swedish chemists which invariably included nitrogen and oxygen. It was not until 1927 that Marden and Rich in the Westinghouse research laboratories produced a sample of vanadium metal of 99.9% purity, using a calcium reduction process in a ' bomb ' process set off with potassium or sodium as charger.

Vanadium's position today, 50 years after its recognition as a potential metal of industry, is rather different from what might be expected when such a struggle has gone on to produce the pure metal. Of its compounds one need only mention vanadium oxide catalysts both in the organic field, for production of phthalic anhydride and maleic acid, for example, and in the production of sulphuric acid as alternatives to platinum catalysts. There have been varied applications of vanadium compounds in marking inks, in dyeing with aniline black, in vanadium glasses, in insecticides and pharmaceuticals and miscellaneous other uses. As for the pure metal, although like titanium it can be produced by thermal decomposition of the iodide and like titanium is a powerful cleanser in steel-making, unlike titanium it has not found extensive applications as the free metal which was so laboriously extracted. In metallurgy only in ferrous and non-ferrous alloys has Sefström's element, now known as a brilliant white metal harder than quartz, proved invaluable.

The manufacture of phthalic alkyds

A RECENT estimate shows that a quarter of all the whole (crude) tall oil and half of all the refined tall oils made in the United States end up as surface coatings, core oils, linoleum and other resin products. According to the U.S. Tall Oil Association, manufacturers of more complex resins like alkyds are also increasing their use of tall oil.

The phthalic alkyds are the most important kind of alkyds and more than 90% of all alkyds are phthalic based. Phthalic alkyds are simple to make and some are still made in direct-fired open kettles. However, higher standards of quality and price competition have nearly eliminated such operations. As a rule, plants are modern, using large, closed, stainless metal kettles with agitators, with close temperature control using indirect heating and cooling, and with accurate measuring devices for all ingredients.

One frequently used procedure for making tall oil modified phthalic alkyds is to heat the tall oil with the desired polyols at esterification temperatures. After an hour or so, some of the water formed in the reaction has distilled out and the partially reacted mixture is nearly homogeneous. The phthalic anhydride is then added and the heating continued at some prescribed temperature, depending on the polyols used, until the desired acid number and viscosity are reached.

Tall oil may also be used together with any of the natural glyceride oils to make oil modified alkyds. A common practice is first to heat the glyceride oils at esterification temperatures with the desired polyols. The polyols thereby interesterify with the glyceride oils and some or all of the glyceride oil is reduced to mono-esters or di-esters. Any residual polyol is more soluble in these than in the natural triglycerides. The tall oil and the phthalic anhydride are then added and heating continued at some prescribed temperature to a desired acid number and viscosity.

In many instances, especially where agitation is adequate, all ingredients are added at the start and the cooking proceeds much as in simple esterification. Mineral spirits are refluxed to remove the water formed in the reaction and to seal the kettle against air.

Phenol handling

ALTHOUGH phenol today is a basic raw material, used in huge quantities by many industries, it was originally used as an antiseptic. Phenol was, in fact, the first widely used antiseptic; early production was sold entirely for that purpose. Near the end of the 19th century, phenol found use in the synthesis of dyes, the newly discovered aspirin and one of the first high explosives, picric acid.

Phenol was first manufactured commercially by distillation from coal tar in 1860; it was in 1875, at what is now Monsanto's Ruabon works, that phenol was first produced on a commercial scale in the United Kingdom. The first synthesis was worked out in 1867, by sulphonation of benzene.

These facts are recalled in an illustrated booklet issued by Monsanto Chemicals Ltd., which provides general information on phenol and indicates how the hazards of handling this highly inflammable material can be reduced to a minimum. The booklet, 'Phenol Facts and Handling,' makes a timely appearance about the same time as the A.B.C.M. Safety Conference at Harrogate.

For unloading or transferring, phenol is melted and heated to about 70°C. After melting, it may be transferred like any other liquid—by gravity flow, pumping, vacuum or by blowing with air pressure. Centrifugal and turbo pumps are most widely used and are quite satisfactory. The selection of pumps for specific operations depends upon the quantity of liquid to be moved, the various elevations, pipe spans and temperatures of phenol when pumped. In maintaining pumps in operation, long-fibre asbestos lubricated with graphite gives reasonable service as pump packing.

Rubber hose is not recommended for transfer lines; they may be of nickel, steel or stainless steel. Precautions must be taken to prevent the liquid phenol from cooling and crystallising in pipelines. Outside lines, especially, should be protected by standard magnesia or fibrous glass insulation and should be provided with $\frac{3}{8}$-in. tracer steam lines running inside the pipe covering. If lines are out of doors, insulated pipes should be wrapped with roofing paper for weather protection of the insulation. Especially long outside lines in cold climates should be steam jacketed. Short lines inside heated buildings should have tracer steam lines on the underside of the pipe, but no insulation is needed if more than 100 p.s.i.g. of steam pressure is carried in the tracer line.

Riveted or welded tanks are satisfactory for storing phenol. Steam coils for melting out may be installed either inside or outside the tank. The latter is preferable because in the case of a steam leak no dilution of the phenol can take place. Contact with iron, copper or bronze will cause discoloration. If a water-white colour is to be maintained, tin-lined, stainless steel or nickel construction should be used. Mild steel clad with stainless steel or nickel is quite satisfactory. Molten phenol readily attacks aluminium, magnesium, lead and zinc. Consequently these metals should not be used in the storage or piping system. If good colour is not important, iron may be used. A further fact to bear in mind is that prolonged heating and frequent melting will tend to discolour the material.

As well as hints on the handling, storing and transferring of phenol, a brief history of the discovery and development of phenol is also included, while other sections deal with protective clothing for operators and first-aid treatment, fire precautions, unloading small containers and road tankers. In addition, there is information about the various grades of phenol available and its physical properties, etc.

Treasure hunt at Kure Beach

DISASTER overtook the celebrated sea-spray-corrosion testing site at Kure Beach, North Carolina, U.S.A., when thousands of valuable specimens were torn by a recent hurricane from racks 80 ft. from the ocean and buried deep in the sand by wind and waves that reduced the area to a shambles. When a carefully prepared specimen has been under test for 15 years or longer as some of these specimens had, it has acquired a value in time that can hardly be estimated and cannot be replaced. Small wonder, then, that the aid of U.S. Marines equipped with mine detectors has been enlisted, in what might fairly be described as a treasure hunt, to retrieve the buried specimens.

The racks formed part of International Nickel Co.'s corrosion testing station, which embraces facilities for studying the behaviour of materials in sea air at Kure Beach and salt water at nearby Harbor Island. Activities at this station have yielded information on how bare and coated metals, woods, plastics and cordage are able to resist the corrosive effects of salt water, salt spray and sea air.

It is expected that most of the specimens will be recovered. A larger test lot at Kure Beach, about 800 ft. from the ocean and in which 30,000 specimens are exposed to atmospheric attack, was far enough back to escape damage by water.

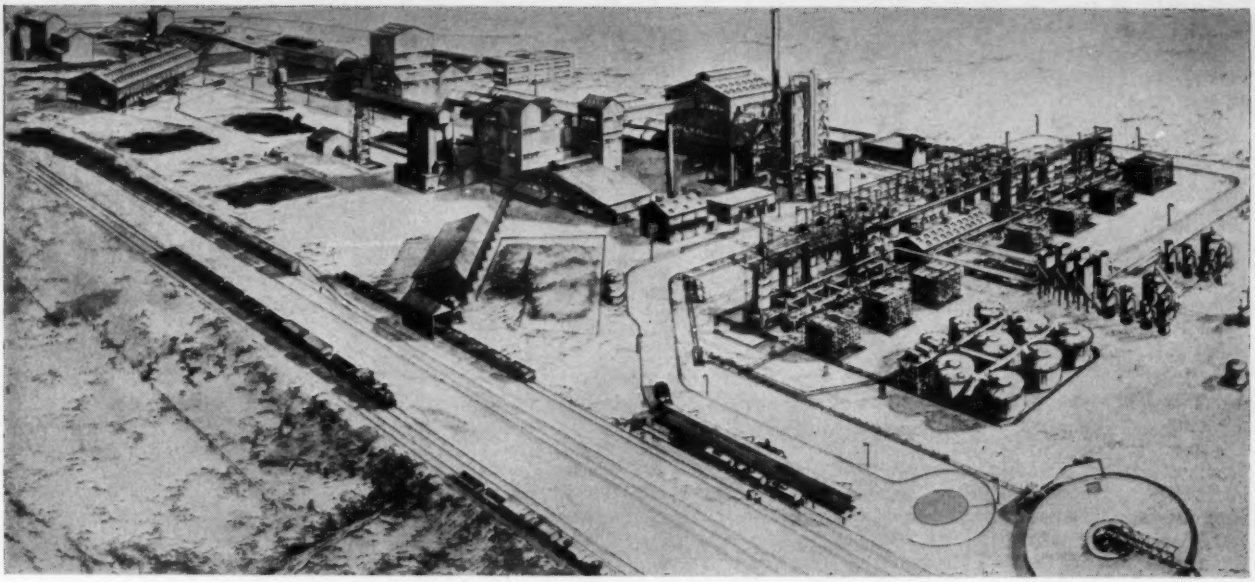
Bringing natural gas to Britain

BILLIONS of cubic feet of natural gas are running to waste in the oilfields of the world and the problem has always been transporting this gas to the great consuming areas of the world. But this gas, after all, is one with which we are very familiar and, when cooled, it shrinks to one six-hundredth of its usual volume and can be stored safely at atmospheric pressure. The Americans have developed a revolutionary method of transport—a new form of cheap refrigerated tanker which makes use of a lining of balsa wood. While the gas industry is still searching energetically and hopefully for natural gas in Britain, therefore, it is also giving consideration to the possibility of bringing natural gas to the U.K. in tankers from America or the Middle East, particularly in the light of a report from a technical mission which was sent to the United States. The scheme is believed to be technically sound. Preliminary estimates show a cost of gas per therm considerably lower than carbonisation costs.

These prospects of obtaining cheap supplies of natural gas in Britain were outlined by the Minister of Fuel and Power in the House of Commons when he reviewed the country's resources of coal and other fuels recently. He said that the public utilities and some of the great industries, such as steel, were doing a first-class job in fuel efficiency, but he could not say the same of the vast number of miscellaneous industries. There were too many antiquated boilers still in use; they have even found one reciprocating engine that was puffing away in its hundredth year of activity. This had to change and change fast.

Automatic Control of Distillation Processes

Readers of Mr. A. Pollard's first article on this subject in our November issue will be interested to note that the second article is to appear in January. This will go into more detail and discuss actual examples of completely instrumented systems.



Artist's impression of the new factory at Widnes when completed.

SULPHURIC ACID AND CEMENT FROM ANHYDRITE

Construction of a £5-million factory at Widnes, Lancashire, to produce some 148,000 tons p.a. of sulphuric acid and 132,000 tons of cement clinker from anhydrite, is in an advanced stage. The United Sulphuric Acid Corporation Ltd., who are building the factory, recently invited the Press to see the progress that has been made. Here we give the story behind this project and describe the plant and processes used. In addition, we describe the plant erected by the Associated Portland Cement Manufacturers Ltd., adjacent to the sulphuric acid works, for converting the clinker to Portland cement and for packing and distributing the finished cement.

THE BACKGROUND STORY

SULPHURIC acid is most easily and cheaply made from sulphur, but this method has two drawbacks. Firstly, most of the world's sulphur comes from Texas and costs dollars. Secondly, as world industry expands, the ever-growing demand for sulphuric acid may outstrip the available sulphur supplies; three years ago there was a threatened 'sulphur famine' and, although the threat has largely disappeared, it may return.

The commonest alternative raw material is pyrites, a sulphur-bearing mineral, but this too has to be imported into Britain.

The only suitable sulphur-bearing material available in large quantities in Britain is calcium sulphate in the form of anhydrite, of which immense underground deposits are known to exist. Anhydrite can be used to manufacture sulphuric acid and cement clinker in roughly equal quantities.

Early development of the anhydrite process was slow and costly. Two experimental kilns were built in Germany during the first world war, but operating difficulties persisted until the 1930s. After research in Britain, Imperial Chemical Industries Ltd. started one kiln at Billingham in 1930 and, having overcome some initial troubles, a second kiln in 1935; these have run ever since and they now produce annually about 100,000 tons of sulphuric acid and a similar quantity of clinker, which is made into Portland cement.

Formation of U.S.A.C.

When the sulphur crisis arose in 1951 the chemical industry, which depends on large supplies of sulphuric acid for making its own products, became seriously concerned. In this crisis I.C.I. offered to license their knowledge and experience of the anhydrite process to the large industrial users of sulphuric acid. Eleven such users formed the United Sulphuric Acid Corporation Ltd., under the chairmanship of Mr. F. G. C. Fison, and I.C.I. agreed to act as technical advisers to U.S.A.C. for the construction of the new factory at Widnes to produce sulphuric acid and cement clinker from anhydrite and other indigenous raw materials.

The following are the member-firms of U.S.A.C., with an abridged list of products in the preparation of which they will use the acid made at Widnes (a list which, incidentally, gives some indication of the important and immensely varied applications of sulphuric acid):

The Alumina Co. Ltd. Aluminium sulphate in various forms and qualities for use in paper making, water purification, colour making and pharmaceutical preparations.

Thomas Bolton & Sons Ltd. Sulphate of copper; processing non-ferrous metals.

British Celanese Ltd. Celanese textiles for clothing fabrics; celanese plastics, including transparent film, safety sheeting and hygienic food wrapping.

British Enka Ltd. Viscose yarn for tyre cord and viscose staple for fabrics.

Clayton Aniline Co. Ltd. Dyes and dyestuff intermediates.

Courtaulds Ltd. Viscose yarn for tyre cord, viscose staple for spun rayon and blend fabrics and *Fibrolane*-regenerated protein fibres for fabrics.

James H. Dennis & Co. Ltd. Sulphate of copper.

Fisons Ltd. Fertilisers, etc.

I.C.I. Ltd. Twelve thousand products, including heavy chemicals, fertilisers, explosives, paints, non-ferrous metals, medicinal drugs, dyestuffs, plastics and zip fasteners.

McKechnie Brothers Ltd. Sulphate of copper, lithopone, electrolytic copper cathodes and electrolytic copper powder.

Transparent Paper Ltd. Transparent cellulose film.

Raw materials and finished products

Anhydrite, the principal raw material for the Widnes factory, will be supplied by British Plaster Board (Holdings) Ltd. from their Long Meg mine in Cumberland, which has been specially developed for this purpose.

The anhydrite process, as stated earlier, produces sulphuric acid and cement clinker in roughly equal amounts. As there is a large demand for cement in the Merseyside area, Associated Portland Cement Manufacturers Ltd. have agreed to buy the clinker from U.S.A.C. and to make Portland cement from it in a new cement works which they are building adjacent to the Widnes acid plant.

The sulphuric acid itself will be bought in agreed quotas by the member-firms of U.S.A.C. for their own consumption.

The Widnes factory will use about 240,000 tons p.a. of anhydrite, from which about 148,000 tons of sulphuric acid and 132,000 tons of cement clinker will be produced. This output of acid represents something like 7½% of Britain's present total acid production, and will thus make a substantial contribution to the national economy; by replacing the use of some 53,000 tons of imported sulphur, it will also save the expenditure of about $2 million a year.

Provision is made for a future 50% increase in the capacity of the factory.

Building the Widnes factory

The total cost of the Widnes project is in the neighbourhood of £5 million. The process to be used in the factory is essentially that developed by I.C.I. at Billingham, and I.C.I.'s responsibilities as technical advisers to U.S.A.C. cover all aspects of the project from provision of technical design data to assistance with initial operation of the factory; I.C.I. have also provided a team of engineers and inspectors under a construction manager to supervise on behalf of U.S.A.C. the construction of the factory by the contractors.

The main contractors for the construction of the complete factory are Simon-Carves Ltd., designers and builders of heavy chemical plant, with over 40 years' experience of sulphuric acid plant construction; their contract for the Widnes factory amounts to about £4 million, and they have a licence agreement with I.C.I. under which they can build plants of this type in any part of the world.

Collaborating with the main contractors are Simon Handling Engineers Ltd., specialists in large-scale industrial handling plants. They are responsible for the materials handling and preparation equipment at Widnes, their share of the work amounting to a little over £1 million.

The factory is built on a site of some 66 acres, which was acquired from Widnes Corporation. About 600 men, most of them locally recruited, are at present employed on construction work by Simon-Carves Ltd. and their various sub-contractors, with a nucleus of Simon-Carves' foremen and other supervisory staff under the direction of their site agent. The formal contract for construction was signed in October 1952, and the clearing and levelling of the site were begun the same month; the first consignments of plant equipment were delivered in March 1953, and the first unit of the factory is due to be commissioned in April 1955. The factory will thus have been put into production in 2½ years from the beginning of work on site.

About 99% of the factory is of British origin and manufacture, the principal exception being a limited amount of specialised aeration equipment which was obtained from the Continent. In view of the national importance of sulphuric acid supplies, official aid was available in case of necessity, one instance being the intervention of the then Ministry of Materials when difficulty arose in obtaining some hundreds of tons of steel plate for the manufacture of the kilns.

The building of the factory has involved a substantial amount of work beyond the boundaries of the actual site. The largest work of this kind was the building of a pumping station at Fidler's Ferry on the River Mersey and the laying of 2½ miles of 24-in. underground pipeline to bring water from Fidler's Ferry to the Widnes factory. Another substantial undertaking was the laying of the 36-in. main drain (believed to be the largest alkathene drain in Britain) through which the plant effluent is taken away; traffic on the St. Helens canal was stopped for nine days while a section of the canal was emptied to enable the drain to be laid beneath it and, while the drain was being installed under the adjacent railway line, it was necessary to freeze the ground artificially to prevent leakage of water into the excavations.

SULPHURIC ACID PLANT AND PROCESS

The anhydrite process consists fundamentally in heating an accurately proportioned mixture of calcium sulphate with materials containing carbon, silica, alumina and ferric oxide, thus simultaneously producing cement clinker and gases containing sulphur dioxide. The SO_2 gas is converted to sulphuric acid by the orthodox 'contact' process.

The raw materials to be used at Widnes in addition to anhydrite are coke, sand and shale. Coal is also used, not primarily as a raw material but in pulverised form for firing the kilns in which the mixture is heated; its ash, however, inevitably forms part of the mixture.

The anhydrite, as stated, will come from Cumberland. The other materials are available locally.

The process comprises the following main stages:

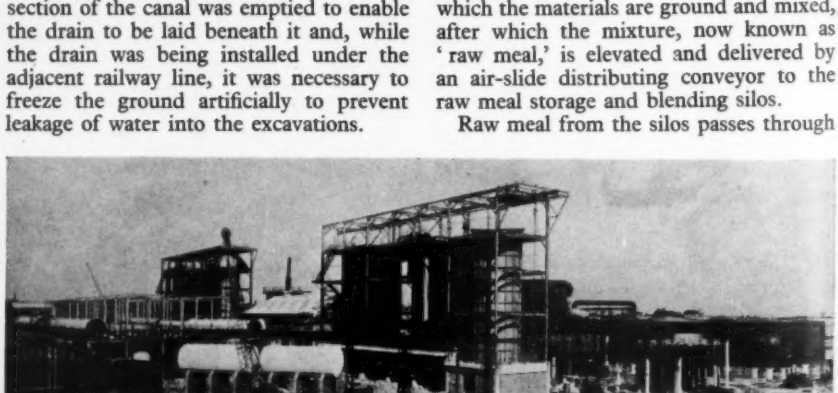
Raw materials handling and preparation

Anhydrite is delivered dry by rail in 25½-ton wagons. It is received by rail hopper and skip hoist, and can either be conveyed to a 12,000-ton storage dump for subsequent reclaiming by mechanical excavator and travelling hopper or it can be conveyed direct to a pair of crushers and elevated thence to a storage bunker.

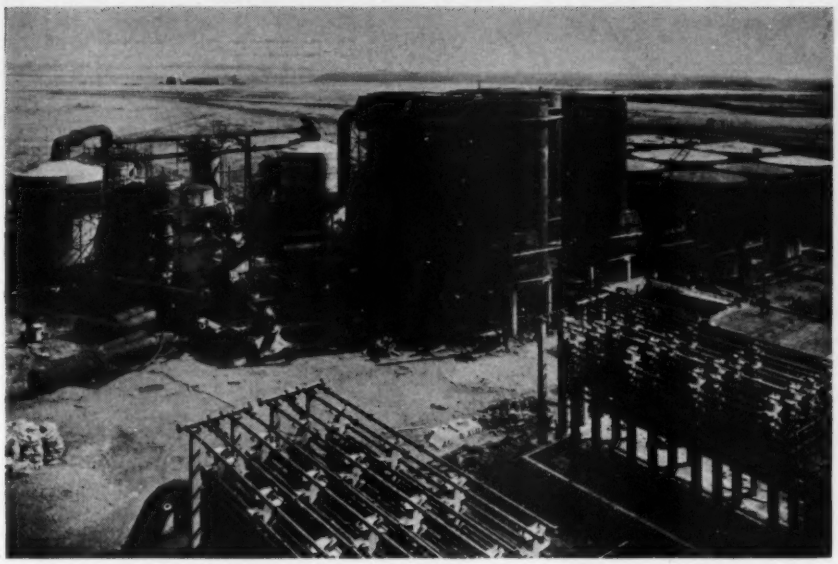
Sand, shale and coke are transported by angle hoist to wet storage bunkers, from which they are delivered to two rotary driers heated by combustion gases from oil burners; one drier treats sand and shale, the other being reserved for coke only. The dried materials are taken by a gravity bucket conveyor to dry storage bunkers.

Below the dry storage bunker outlets is a battery of automatic weighers feeding to a pair of belt conveyors. The weighers are electrically controlled and interlocked to give a feed of the correct proportions for producing a first-grade Portland cement clinker. The two conveyors deliver the proportioned feed to two ball mills, in which the materials are ground and mixed, after which the mixture, now known as 'raw meal,' is elevated and delivered by an air-slide distributing conveyor to the raw meal storage and blending silos.

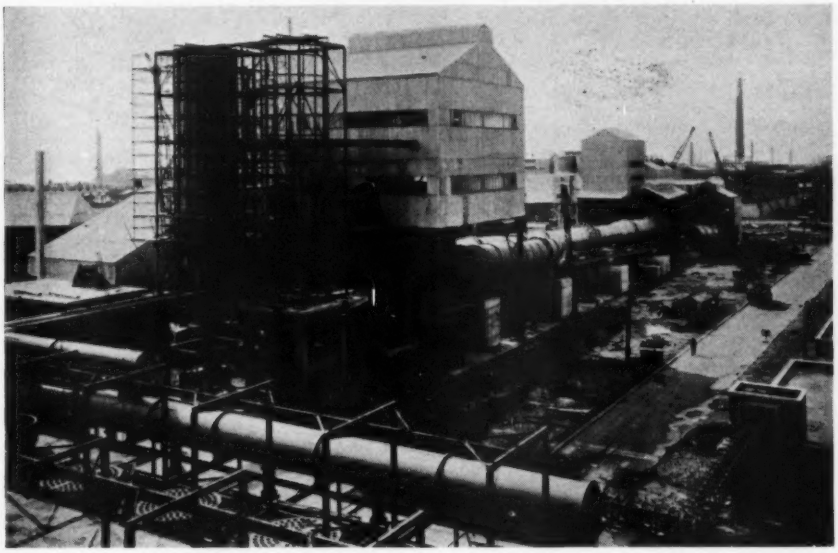
Raw meal from the silos passes through



Drying towers, absorber towers and tail gas scrubber towers, with acid coolers and acid storage tanks on right.



Another view of the Widnes plant. *Left:* **Oxidation units, comprising catalytic converters and heat exchangers.** *Centre:* **SO_3 coolers.** *Right:* **Acid storage tanks. In the foreground, acid coolers.**



Kilns and kiln feed house, with cyclones and partly constructed gas cooling towers in front of feed house. In the foreground is part of gas distribution main to electro-precipitators.

special feeding devices to the feed end of the kilns.

Coal is conveyed from dump to a storage bunker feeding to three mills, which provide pulverised coal at the firing end of the kilns.

Production of SO_2 and cement clinker

The two rotary kilns, each 355-ft. long, are the heart of the anhydrite process. They are in general similar to orthodox cement kilns, but the linings and certain other details are specially modified.

Pulverised coal is fired at the opposite end of the kilns to that at which the raw meal enters. The silica, alumina and iron oxide in the sand, shale and coke combine with the lime in the anhydrite to form cement clinker, which in simple terms is a combination of the alumino-ferrate and silicates of calcium.

The clinker leaves the kilns through tubular coolers and is received in hoppers, from which it is taken by shaker conveyors to jaw crushers, and is then elevated to automatic weighers; from these it is fed to clinker bunkers by conveyors with travelling trippers, and from the bunkers it is elevated and conveyed through an overhead gantry to a 10,000-ton covered clinker store. From the store it is elevated to another pair of weighers, and is then conveyed to the adjacent works of Associated Portland Cement Manufacturers.

Gas purification

The gases leaving the two kilns are kept in two separate streams, which are cleaned, cooled and converted into sulphuric acid by what are in effect two similar plants in parallel.

The kiln gases are hot and dusty and contain mainly sulphur dioxide, oxygen and nitrogen. The bulk of the dust in each stream of gas is removed in a smoke box and cyclone; the gas then passes to a cooling tower over which clarified river water is pumped, cooling and saturating the gas and removing most of the remaining dust.

Each stream of cleaned and saturated gas then passes through a set of four pairs of electro-precipitators, in which the last particles of mist and dust are removed. In order to allow any two precipitators to be taken out of service for cleaning or repair, an extra pair of precipitators is provided which can be used on either gas stream.

Conversion of SO_2 to SO_3

The sulphuric acid plants, as stated, operate on the orthodox ' contact ' system, the two units being identical in all respects except that one of them incorporates an oleum tower.

Each gas stream from the precipitators passes through a drying tower in which water is removed by counter-current circulation of strong sulphuric acid. The dried gas then passes through blowers into a multi-stage converter, in which, in the presence of a vanadium catalyst, the sulphur dioxide and oxygen in the gas combine to form sulphur trioxide; this process of oxidation is exothermic, and heat exchangers are accordingly used between the stages of conversion in order to maintain the gas at a suitable temperature. The sulphur trioxide is then passed through three annular cooling towers in series, the last of these towers being water cooled.

Absorption of SO_3 to form sulphuric acid

Each sulphur trioxide stream then passes through two absorber towers in which it is absorbed in strong sulphuric acid, part of the sulphur trioxide in one stream having been absorbed in the oleum tower. The strength of the acid leaving the absorbers is kept constant by dilution with water, and the net ' make ' of acid thus obtained is pumped to storage. From the storage tanks it is pumped through loading arms to either road or rail tankers.

Traces of unconverted sulphur dioxide in the gas streams leaving the absorbers are removed in tail gas scrubbing towers before the tail gas is released to atmosphere.

Town's water is used for sulphuric acid dilution. For cooling purposes clarified river water is pumped from the River Mersey at Fidler's Ferry 2½ miles away, rejoining the river further downstream after use on site.

CEMENT GRINDING AND PACKING PLANT

The clinker formed of the residue of the kiln in the process to be used at Widnes is, chemically, identical with the Portland cement clinker produced by the normal process.

By agreement with U.S.A.C., the Associated Portland Cement Manufacturers Ltd. have erected, adjacent to the new works and to the east of Tanhouse Lane, a plant for grinding this clinker to convert it to Portland cement and for packing and distributing the finished product. The A.P.C.M. works occupies an area of 3.2 acres, and the plant has been designed to produce and distribute 120,000 tons p.a. of cement.

Scheme of operations

The plant flow is briefly as follows:

The cement clinker, having passed the recording check weigher, is fed by vibrating feeder (the weigher and feeder form part of the U.S.A.C. equipment) to the 24-in.-wide intake belt conveyor and delivered to a 250-ton-capacity storage bunker, the conveyor being supported in a structural-steel gantry erected between the U.S.A.C. store building and the storage bunker; interlocks are provided to ensure sequence operation between the U.S.A.C. equipment and the intake conveyor.

Gypsum will arrive at the works by rail and be discharged by hand at the intake hopper and elevated to a 50-ton-capacity storage bunker or to an open stockpile.

The clinker and gypsum (approximately 95% clinker to 5% gypsum) are extracted from their respective bunkers by gate-controlled belt feeders, the one supplying clinker being speed-controlled by adequate weigher mechanism to ensure correct blending and feed rate. An inclined conveyor discharges the blended feed direct into the feed chute of a four-compartment, 1,200-h.p. grinding mill.

The grinding mill is of A.P.C.M. standard construction 8 ft. 4½ in. dia. × 45 ft. in length, the drive being by torque shaft from the 1,200-h.p. B.T.H. synchronous induction motor through double-helical, double-reduction B.T.H. gear unit. The mill ancillary equipment includes barring gear, shell water-cooling sprays, cooling tower and reek and dust-extraction plants.

Portland cement handling and packing

The product from the mill (Portland cement) is transported to either of four 60-ft.-high, 1,250-ton-capacity storage silos by air conveyor, chain and bucket elevator and distribution air-conveyor system.

Extraction from the silos and delivery to the packing plant is by a further system of air conveyors and elevator. The 12-spout *Fluxo* rotary packer has a capacity of some 120 tons/hr. From the packers the bags discharge to a horizontal loading conveyor and thence by chutes to the retractable lorry-loading belt conveyor.

Bulk loading extraction is by air conveyor direct to lorry.

The plant is electrically operated throughout, the mill motor being controlled direct from the Electricity Board's 6-kv., three-phase system, while all other services are 415-v., three-phase, or 240-v. and 110-v., single-phase, through stepdown transformers.

In designing the plant special emphasis has been laid on the elimination of the dust nuisance and dust-extraction plants or filters have been installed at all essential points and, in addition, the plant has been piped to a central vacuum-cleaning system with hose connections at each of the various floors.

An office block, laboratory, canteen, sundries store, main sub-station, workshops, repair garage and covered standing space for 30 lorries are also provided.

The contractors were Sir Alfred McAlpine & Son Ltd. Messrs. Oscar Faber & Partners designed the reinforced-concrete work.

The output from this plant at Widnes will all be delivered by road into the Liverpool area and Wirral Peninsular.

Japan's Chemical Industry Prospers

THE chemical industries in Japan have a good post-war record, for their level of production has been higher than that for the entire mining and manufacturing industries. However, much remains to be done if international standards in quality and quantity of output are to be reached.

The two main obstacles are shortage of capital and backward technique, and the fact that much of the progress made since the war has been due to external assistance, financially and technologically.

Technical help has been forthcoming mainly from American firms, with which Japanese companies have affiliated in one way or another. Direct financial investment in Japanese chemical firms, coupled with technological contracts, has been substantial, amounting to about one-fifth of the total of such contracts.

Chemicals constitute a staple Japanese industry, ranking fourth next to the textile, foodstuffs and primary metals industries. In 1952 the chemical industries accounted for some £500 million of the national product, if we included organic and inorganic chemical products, oils and fats, and pharmaceuticals, but exclude chemical fibres. This amounts to about 10.6% of the total for all manufacturing industries.

In a 60-page illustrated survey of Japan's economy, the *Financial Times* devotes a page to the principal chemicals and allied products produced in Japan, these being sulphate of ammonia, calcium cyanamide, dyestuffs, petroleum products, caustic soda, soda ash and soap. Perhaps the most spectacular progress has been made in the production of sulphate of ammonia, which has been stepped up since the war as part of the food production drive, until in 1953 it was able to operate on an unprecedented large scale, with a productive capacity of about 2,892,000 tons and an annual output of about 1,856,000 tons (excluding urea and sulphate of ammonia produced as a by-product). Japan was able not only to cover her domestic requirements, amounting to about 1½ million tons, but also to export more than ½ million tons. In export trade, the industry has the advantage that Japan is near the Asian markets.

Recently the use of fertiliser not containing sulphuric acid has been encouraged, and the 1952-53 output of fertilisers was about 50% above the pre-war peak. On the other hand, partly because of increased production of sulphate of ammonia, manufacturers of calcium cyanamide have been obliged to hold stocks of some 100,000 tons, depressing the market considerably. Plans for the modernisation and rationalisation of the industry include: (1) adoption of large-sized closed electric furnaces, whereby more than 15% reduction in the cost of carbide is reported possible; (2) installation of equipment for granular products; and (3) sideline production of ferro-alloys and cement, and operation of the acetylene and cyanamide derivative industries. Some of these plans have already begun to take effect.

In dyestuffs, Japan is not doing so well as in pre-war days. Costs of dyestuffs production are reported to be 30% higher in Japan than in the United States. The ban on exports to Communist China is another limiting factor. In 1945 dyestuffs output had fallen to 652 metric tons, but by 1949 the industry's capacity had been restored to 16,000 tons, 70% of pre-war.

About 372,000 tons of caustic soda and about 275,000 tons of soda ash were produced in Japan in 1953, being 83% and 108%, respectively, of pre-war levels. The increase in capacity is larger for the electrolytic process than for the ammonia process, which may be attributed to the fact that the electrolytic process requires a smaller volume of crude salt per unit of product than the ammonia process, that soda of high purity produced by the mercury process is adapted for chemical fibres and that use of chlorine has been extended to the production of condiments and synthetic resins. The cost of importing crude salt has raised the cost of soda production.

Output of the Japanese soap industry in 1953 was 190,000 tons, compared with 264,000 tons in 1939. For this industry also, in view of intensified competition, measures are being taken to enable the industry to compete in the world export market. At present Nippon Yushi K.K. and K.K. Marumiya are trying to rationalise operations by installation of continuous fat-splitting units and continuous soap-manufacturing units.

ION EXCHANGE

I. Theory, materials, new techniques

By J. M. Hutcheon, B.Sc.

REFERENCES to ion exchange now appear in the world's leading journals at an average rate exceeding one per day. Perhaps for this reason no up-to-date and exhaustive treatise exists on the subject and such a book is daily becoming more difficult to write. Review papers and conferences are frequent, however, and are tending to be devoted to selected areas of the field. The reviews are mostly mentioned in the appropriate sections of this article. The collected papers of the conferences provide valuable up-to-date accounts; among the more important conferences recently reported are those organised by the New York Academy of Sciences (New York, 1952), the Deutsche Bunsengesellschaft[2] (Leverkusen, 1952) and the Society of Chemical Industry[3] (London, April 1954).

Ion-exchange materials are now as frequently used as many of the classical reagents in analytical and biochemical laboratories and these research applications form a larger proportion of the original references than the industrial applications which are of greater concern at present. Accordingly this review has been weighted somewhat in favour of the latter. Fundamental research on the nature of ion exchangers and on the ion-exchange process continues at a high level of activity. The physical chemistry is rather involved, but in view of its importance to future practice an attempt has been made in this review to deal with the salient features.

THEORY

Equilibrium

The correct mathematical formulation of the equilibrium state of an ion-exchange process requires that the true stoichiometric exchange be discriminated from any molecular adsorption which may take place on the exchanger. If the latter type of process can either be neglected or allowed for, then the expression which should apply for the reaction

$$AR + B^+ \rightleftarrows A^+ + BR$$

where R denotes the fixed anion in a cation exchanger, is

$$\frac{(A^+)\,(\overline{B}^+)}{(\overline{A}^+)\,(B^+)} = K_a$$

where K_a is the thermodynamic equilibrium constant. The parentheses indicate activities and the bars above the symbols indicate that the activities refer to the resin phase.

In order to establish this equation for any given exchange it is necessary to know, firstly, the concentrations of both ions in both phases and, secondly, the appropriate activity coefficients. Of these, only the concentrations of the ions in the solution phase can be obtained by straightforward methods. The concentrations in the resin phase cannot be determined directly from these, since the solvent is also taken up by the resin, partly as 'free' solvent and partly as solvated ions. This, as well as any molecular adsorption, has therefore to be taken into consideration. Activity coefficients for many salts in pure solution are tabulated, but there is little data for mixed solutions, and the appropriate values have to be obtained by application of semi-empirical formulae such as Harned's rule. The activity coefficients in the resin phase present even greater difficulties. Davidson and Argersinger,[1] however, have recently described methods for evaluating all these quantities and have succeeded thereby in obtaining excellent correlation of the experimental results for the sodium/hydrogen exchange on a cation resin over a range of ionic strengths. Similar work has been done for the potassium/hydrogen exchange by Davies and Yeoman,[4] who conclude that the resin phase may be fairly regarded as an aqueous mixture of completely dissociated electrolytes. Faucher and Thomas have studied the exchange of caesium for potassium between montmorillonite clay and aqueous solution and have presented data for the activity coefficients of the cations in the mixed clay phase.

Once the appropriate equilibrium constants have been determined for two systems involving the exchange of an ion B with the exchanger in the A form and similarly the exchange of another ion C with the exchanger in the A form, the selectivity of the resin for the pair of ions B and C may be determined as the ratio of these equilibrium constants. Bregman[1] has reported experiments showing how, for cation resins, this selectivity varies with resin structure, nature of the acidic group, mole fraction of the exchanging ion in the resin phase, resin capacity, external ionic strength and temperature. Many commercial resins are now based on polystyrene with divinyl benzene as cross-linking agent. The proportion of the latter used, therefore, markedly affects the resin structure, and the effect of varying it on swelling, selectivity and rate of exchange has been studied by several workers (for example, Pepper and Reichenberg[2]). Ultimate capacity is not very much affected in this way, however, and to vary this property the active groups have been partly removed by hydrolysis to different degrees. When this was done to a nominal 16% cross-linked resin, the selectivity for sodium over hydrogen was found[6] to decrease with decreasing capacity and to become less than unity for a 50% desulphonated resin. The silver-sodium selectivity increased, however, under these conditions and similar results were obtained with cross-linked pectin exchangers.[7] Cross-linked polyacrylic acids, however, became less selective, for all ion pairs examined, as capacity was decreased. Explanations can only be tentative until further experiments are done with different methods of varying the capacity.

The fruitful hypothesis of Gregor and his school that selectivity can be measured entirely by the swelling characteristics of the exchanger has provoked more work on swelling of resins. The evidence in support of it has been summarised[1] and more recent data in support of this view has been given by Bonner *et al.*[8] Boyd and Soldano,[2] however, have reported a series of measurements which led them to consider that the correlation is not always valid.

Calorimetric methods have also been used[9, 10] to examine ion-exchange equilibria leading to values for free energy changes for the reactions. Marshall and Upchurch[11] derived values for free energy changes for exchange between soya-bean roots and a variety of substances, including not only aqueous solutions of potassium, calcium, chloride and bicarbonate ions, but also clays and ion-exchange resins. One of the conclusions from this work was that Amberlite IR 120 behaved as a multifunctional resin.

A further paper aimed at prediction of equilibrium constants from purely theoretical arguments has been published by Sakai.[12]

Non-stoichiometric adsorption

This complicating factor in the ion-exchange process has received considerable attention recently. For strong base (quaternary ammonium) anion exchange resins,

Gregor *et al.*[13] found no difference in capacity among a series of ions varying from small simple ions like those of the halides to large ions such as *para*-benzene-sulphonate and naphthalene-sulphonate. In very strong (up to 12 M) hydrochloric acid solutions, Kraus and Moore[14] found adsorption of hydrochloric acid by the strong base resin Dowex 1 to proceed to a point where the concentration of acid in the resin phase was of the same order as that in the solution. Similar conclusions were reached from studies of gold solutions in concentrated hydrochloric acid, and the thermodynamics of such systems have been discussed. Evidence for molecular adsorption by weak-base anion exchangers was obtained[15] from measurements with a series of substituted benzoic acids and acetic acid. Such resins were also found to adsorb copper and mercury very slowly by ammine-forming reactions such as:

$$RNH_2 + Cu^{++} \rightarrow (RNH_2.Cu)^{++}$$

In experiments on the absorption of dyestuffs on montmorillonite it was also found necessary[16] to postulate reactions other than simple stoichiometric exchange.

The technique of ion exclusion discussed in a later section is an example of a practical application of non-stoichiometric adsorption.

Kinetics and column design

This branch of the subject was for some time rather neglected compared with equilibrium studies, but has received much attention in the last year. The following lines of attack may be distinguished:

(i) The derivation of mathematical equations for column performance based on assumptions of greater or less generality regarding the nature and relative importance of the diffusion processes occurring;

(ii) The testing of such theoretical equations by column experiments;

(iii) The correlation of column data by semi-empirical equations or by graphical methods analogous to those used in design for other mass-transfer processes;

(iv) Experimental measurements of the overall reaction rate under varying conditions from which the rate-controlling mechanisms may be inferred;

(v) Experimental determination of the rates of various individual steps, or postulated steps, in the total ion-exchange process.

Examples of all these approaches may be found in recent original papers and reviews.

In the mathematical field, Goldstein[17] has published two important papers. The first deals with the general case in which a linear relation between the equilibrium concentration in the resin and solution phases is not assumed. The theory was developed both for 'adsorption' and 'elution' parts of the ion-exchange cycle. Vermeulen and Hiester have also discussed the case where the column is uniformly partially presaturated before exchange. Goldstein's second paper deals with the limiting 'equilibrium' case where diffusion may be assumed to be infinitely rapid. The use of computing machines for handling the resulting equations and even more complicated cases which have not been attempted theoretically has been discussed.[18]

Hagerty and Bliss[19] applied equations assuming linear equilibrium to experimental data for the exchange of copper, zinc and chromium with the calcium form of a cation resin and showed how to use the equations for column design. They concluded that, for the regeneration step, longitudinal diffusion, which was not taken into account in the equations, outweighed the diffusional processes considered.

Gilliland and Baddour[20] postulated a bilinear rate equation which for univalent ions reduces at equilibrium to the mass action expression. The expression was integrated and checked experimentally in batch experiments for sodium-hydrogen exchange on Dowex 50 over a concentration range of 0.001 N to 0.1 N.

By use of the Thomas equations the rate constant was also deduced from 'break through' curves. Analysis of column performance data for different flow rates and particle diameters gave a general expression for the rate constant in terms of particle diameter and Reynolds number. This expression, which successfully correlated the data for both forward and backward exchange runs, includes terms for contributions from both the film and particle diffusional resistances. The evaluation of the term for particle diffusion, however, rests on approximations which have since been improved. Where the exchange reactions produce significant heat effects, the movement of the exchange front can be followed[21] by the progression of a 'hot spot' down the column. A theory has been developed and successfully used to predict the characteristics of this 'hot spot' when a strongly basic anion exchanger is regenerated with alkali.

Graphical methods of design are represented by two Dutch papers[22, 23] describing procedures analogous to the McCabe-Thiele and Ponchon-Savarit diagrams used in distillation column design, and a Japanese paper[24] quotes a correlation of exchange zone height with flow rate and water hardness which is suitable for water-softening column design.

Dickel and Meyer[25] found film diffusion to be controlling when hydrogen and alkali metal ions were exchanged on ion-exchange films. Reichenberg and Pepper[2] measured diffusion rates using granular resins. They reported film diffusion as the controlling step for low-solution concentrations and particle diffusion as controlling when solution concentrations were greater than 1 molar. The rates of sodium-hydrogen exchange in a carboxylic exchanger have been measured and shown to imply diffusion coefficients for hydrogen ion in this resin of the order of one thousandth of the corresponding values in commercial sulphonated polystyrene exchangers. The experiments confirm Bauman's explanation that this is due to the feeble dissociation of carboxylic groups in the resin provided that this dissociation is assumed to follow a simple mass-action law. This 'weak acid' effect is presumably also responsible for the observations of Lewis[27] with bentonite suspensions. By percolating these suspensions through columns of strong acid cation exchangers in various salt forms he could exchange the ions originally on the resin with replaceable ions in the clay. When ammonium, calcium or magnesium was thus transferred, exchange became incomplete at high flow rates, as would be expected. The transfer of hydrogen ion from the resin to the clay, however, apparently took place too rapidly for the experimental variations in flow rate to affect the transfer.

Haagen[2] used titration methods to measure rates of neutralisation of the acid forms of carboxylic and sulphonic resins for variations in swelling, pore size, grain size and temperature.

In point of novelty at least, the most significant recent work in ion-exchange kinetics is the direct determination of self-diffusion coefficients in the resin phase. Boyd *et al.*[6, 28] have used the isotopic tracer technique to measure these in sulphonated polystyrene resins. They studied both anion and cation systems and varied ionic charge, degree of cross-linking, sulphonate group content and temperature. The results of the measurements were interpreted in terms of a modified absolute reaction rate theory. Isotopic tracer techniques were also used by Spiegler and Coryell[29] for similar experiments on ion-exchange (phenol sulphonic) membranes, the diffusion being followed by autoradiographs. For these materials it is relatively simple to determine ionic mobilities, and hence diffusion constants, from specific conductances. The values obtained in this way generally agreed well with those derived from the tracer methods. Schlögl[2] also measured apparent self-diffusion coefficients in both cation and anion resin membranes, using sodium bromide as the external electrolyte for both. He concluded that the mobility of ions in the membranes decreased or increased with increasing concentration according as their charge was of the same, or the opposite, sign to the fixed charges in the membrane.

A treatment of ion-exchange column design has been given by Glueckauf[3] in the form of a differential equation in which the factors leading to departure from equilibrium performance, namely finite particle size, finite film diffusion resistance and finite particle diffusion resistance, are grouped together as an 'effective height of theoretical plate.' Without solving the equation he derives useful general con-

siderations affecting the design of ion-exchange columns. For practical cases the equations can be solved approximately and the E.H.T.P. values converted to an exchange-zone length, which for absorption and displacement chromatography corresponds to the proportion of column ineffectively used. For elution chromatography the equations are a little more difficult, but can still be handled. Thus Glueckauf concludes that it should be possible to design ion-exchange columns by comparatively simple calculations, provided that one avoids irregularities in column packing, with consequent channelling.

PREPARATION OF NEW ION-EXCHANGE MATERIALS

Coals

A German paper[30] on ion exchangers prepared from coal states that brown coals have the highest exchange capacity of all natural coals owing to the carboxyl groups present. Coals containing both carboxylic and sulphonic acid groups may be prepared by activating either brown or hard coals with fuming sulphuric acid at 100°C. for extended periods. Either product is suitable for exchange in the hydrogen form, but hard coal is preferred for neutral exchange, under which conditions brown coal is excessively soluble. A method has been patented[31] for preparing carboxylic exchangers from anthracite by fluidising the anthracite powder at 300° in air containing nitric oxide as catalyst and subsequently boiling the product with caustic soda.

Synthetic resins

The more strictly synthetic materials have been classified in a valuable review by Craig[1] into:

(i) Those prepared by condensation synthesis (phenol-formaldehyde, amine-formaldehyde, phenol-formaldehyde-primary amine);
(ii) Cellulose plus active groups (phosphonate, sulphonate, carboxyl, amine, quaternary ammonium);
(iii) Casein-formaldehyde products;
(iv) Addition polymerisation resins (*e.g.* acrylic or methyacrylic acid plus divinyl benzene, or styrene-divinyl benzene copolymers into which active groups are introduced);

and this classification will be followed where appropriate.

In Japan, cation resins have been made by condensing salicylic acid with formaldehyde and by condensing phenol, formaldehyde and chloracetic acid, followed by a further formaldehyde condensation. Aniline-formaldehyde-polyvinyl alcohol condensation gave an anion resin. The condensations of formaldehyde with phenolphthalein alone or with other phenols to give resins containing both phenolic and carboxylic groups, and of naphthalene sulphonic acid with formaldehyde to give an exchanger containing both sulphonic and carboxylic groups, have been reported by Indian workers. The same authors have described the preparation of polymers from cashew-nut-shell and bhilawan-shell oils by catalytic or aldehyde condensation reactions. These polymers may be sulphonated to give ion-exchange resins containing carboxyl, phenolic and sulphonic groups.

The extraction of heavy chemicals from sea water, demineralising processes, effluent treatment and water treatment are among the interesting industrial applications of ion exchange that will be discussed, along with laboratory applications, in the second part of this review.

The treatment of cellulosic material with phosphorus oxychloride in hexane solution and ammonia to give a phosphoric exchanger has been disclosed.[32]

Charged groups such as carboxyl, sulphonic acid, pyridinium and others have been introduced[33] into filter paper to give ion-exchange papers having better properties than the untreated material for filter paper chromatography. A method has been found[34] for preparing water-soluble polyvinyl phosphates which can be used to esterify the hydroxyl groups of cellulose to give an ion-exchange fabric having a capacity of approximately 3 meq./g.

Other methods of phosphorylating polyvinyl alcohol gave mixed esters insoluble in water and partly cross-linked through the phosphorus atom. They had cation exchange capacities of 4.5 meq./g. or more. These may be regarded as intermediate in type between the condensation and addition polymers. According to further Japanese patents, polyvinyl alcohol has been condensed with benzaldehyde, and methyl methacrylate and glycol dimethacrylate have been condensed using benzoyl peroxide.

Among the true addition polymers, p-vinyl benzene sulphonic acid has been polymerised,[35] thus offering a new route to sulphonic acid exchangers. A patent has been granted[36] for the preparation of anion resins by chlorinating the copolymers of, for example, dimethylstyrene with ethylvinylbenzene and divinyl benzene and treating the resultant product with ammonia. Pepper *et al.*[37] have described the present standard method of preparing strongly basic anion exchangers by treatment of cross-linked polystyrene with chloromethyl methyl ether in the presence of a Friedel-Crafts catalyst, followed by reaction with the appropriate amine derivative.

New types of anion exchangers have been patented[38] which have sulphonium radicals as the active groups and are said to be particularly suitable for removing silica from water. Another new material,[39] recommended for adsorbing acids by ion exchange, is a polyaminealdehyde resin complex containing adsorbed alkyl sulphates.

Resins of standard chemical type are now becoming available in particularly porous form.

Chelating resins

The standard ion-exchange resins do not in general show particularly high selectivity for ions of the same sign. The selectivity improves with increasing cross-linkage, but generally at the cost of slower exchange. Efforts have therefore been made to produce resins analogous to the chelating organic reagents used in analytical determinations of metals. Thus Skogseid in 1948 reported the preparation from linear polystyrene of a polymeric analogue of dipicrylamine which was highly specific for potassium. Other resins with enhanced specificity were made[1] by diazotatisation and coupling reactions carried out on polyaminostyrene. Later, similar materials were prepared from cross-linked polystyrene-divinyl benzene copolymers.

Gregor *et al.*[40] have now prepared highly specific resins by formaldehyde condensations of a number of suitable starting materials. They achieved most success with metaphenylene diglycine, which is analogous to the ethlenediamine tetracetic acid now widely used in analytical work. With this resin they found marked variations in adsorptive capacity with *p*H for several transition elements and the shapes of the absorptive capacity-*p*H curves differed considerably for different elements. Hence cobalt could be selectively removed at *p*H 2.5 and copper at *p*H 6.5 from a solution containing cobalt, copper and iron.

Superior resins of the same type have recently been made[3] by reacting the chloromethylated copolymer of polystyrene and divinyl benzene with an amine, treating the reaction product with chloracetic acid or imido diacetonitrile and finally hydrolysing. Either route gives a resin containing the active group $CH_2N(CH_2.COOH)_2$ and having high specificity for copper.

Electron-exchange resins

Cassidy *et al.* have made further progress with these interesting materials. Much development remains to be done, but the possibility of altering the oxidation state of an aqueous system by passage through a column of solid material has been established. Work has been reported[1, 41] on the preparation of linear polymers of vinyl hydroquinone and copolymers of vinyl hydroquinone or vinyl hydroquinone dibenzoate with a range of vinyl derivatives. The cross-linked polymers were mounted on filter aid in columns and break-through oxidation and reduction curves were established. Manecke[2] has prepared materials with similar properties

by polycondensation of hydroquinone, pyrogallol or pyrocatechol with phenol and formaldehyde.

Properties of resins

A new aspect of resin studies appears from a paper by Griessbach[2] presenting the results of examination of various ion-exchange materials by optical and electron microscopy and by *x*-ray methods. An automatic apparatus has been described[42] for use in the life-testing of resins by repeated cycling. Experiments are reported on the measurement of the conductance of an ion-exchange bed in deionised water or dilute hydrochloric acid solutions. An increase with time is attributed to partial solution of the resin and the measurement of bed resistance is suggested as a sensitive test for the solubility of resins.

Ion-exchange resin membranes

These materials continue to arouse a great deal of interest and some of the work has been discussed in other sections of this review. There has been much speculation about large-scale industrial uses. For these to be successful, however, it is clear that they must be preceded by considerable pilot-scale work. For example, membrane life must be established and satisfactory means of assembling the membranes into cells must be demonstrated.

Experimental work has been mainly concerned with studies of electrochemical properties. The research interest derives largely from the fact that potentials across solution interfaces have long been a subject of physico-chemical research and that the present membranes have far superior physical properties to those previously available. An excellent review article by Sollner[1] puts the new materials into historical perspective in this way and brings together many of the ideas previously presented in papers by his own and other schools.

Scatchard[44] has given new equations for membrane potentials which allow for a number of complicating factors, and Wyllie[45] has derived equations for the potentials across membranes separating mixtures of critical ions and for the simpler case where only two monovalent ions are involved. For this case the simple theoretical relations between selectivity coefficient, transport numbers, electrical conductivities and potentials developed were confirmed experimentally for a range of membrane materials. This work offers what may be a very convenient means of measuring the selectivities of some exchangers, *e.g.* clays, by bonding them into membranes.

It is generally recognised that the glass electrode may be regarded as a membrane having the particular feature of being specific towards hydrogen ions, so that the potential developed may be related directly to the hydrogen ion activities of the solutions which the glass wall separates. Resin membranes are, of course, not specific to particular ions in this way, but under certain conditions may none the less be valuable for measuring solution activities or concentrations. Thus Kressman[46] has prepared membrane electrodes by sealing a short length of 2-mm. diameter sulphonated phenol resin into the bottom of a glass tube. When a known solution containing only one cation is placed in the tube and the assembly surrounded by a similar solution of different concentration, the potential developed across the membrane may under some conditions be taken as a measure of the activity of the external solution. Such membranes have been used successfully in the concentration range 0.02 to 0.001 M. Similar results have been reported from other laboratories.

NEW TECHNIQUES

Ion exclusion

In conventional ion exchange the solute is ionised and the medium water. Recent work has examined the behaviour of resins when one or other of these conditions does not hold. The phenomenon of 'ion exclusion,' as originally described, was based on the principle that the resin phase, by virtue of its charged groups, was less accessible to ionised compounds than those substantially unionised. The separation of hydrochloric acid from acetic acid was quoted as a typical application of this principle. It has now been shown[1] that the phenomenon is of very general application and that other factors enter, molecular size for example. The distribution coefficients between the resin phase and the external phase have been found to vary considerably among non-ionic materials and in consequence many pairs of such materials which dissolve in water or other polar solvent can be separated simply by elution with the solvent. Separations described include acetic acid from glycerol, glucose from acetone or methanol and acetone from formaldehyde. The fractionation of a mixture of sucrose, glycerol, triethylene glycol and phenol has also been achieved.

Chromatographic separations of this type have been quantitatively described[47] by an adaptation of the Mayer-Tompkins method and the dependence of H.E.T.P. upon column variables shown to follow the patterns established for conventional ion exchange. The examples studied were the separation of sodium chloride from ethylene glycol and acetone from ethylene glycol.

Non-aqueous ion exchange

In the above examples one or more of the solutes to be separated were undissociated, but the solvent was normally water. Systems in which the solutes are ionised but the solvent is non-aqueous have also received attention. If the resin is in its normal hydrated condition and the solvent is immiscible with water, then a liquid-liquid transfer step precedes the ion-exchange step and no swelling of the resin occurs. If the solvent is miscible with water, some may enter the resin phase causing swelling. Exchange can occur[49] in completely non-polar solvents, where swelling is less, but takes place to a less extent and more slowly than in polar solvents. It has also been observed[50] between a liquid ammonia solvent phase and a cation resin which was completely dehydrated before use. The prediction of non-aqueous ion-exchange column performance has been studied.[51] It appears very probable that non-stoichiometric absorption is often an important complication and it will prove difficult to unravel the various competing mechanisms sufficiently to give a complete quantitative explanation of the general case.

Rather more straightforward applications of non-aqueous solvents have been reported in which a partly organic phase is used as an eluting agent, *e.g.* acetone-water-hydrochloric acid mixture for extracting[52] silver and gold complex cyanides from an anion resin on which these metals, together with iron, copper, nickel, zinc and cobalt, have been absorbed. Similarly thenoyltrifluoro acetone dissolved in dioxane-water mixture has been used to separate[54] yttrium from europium on cation resin columns. In such applications the solvent essentially plays a role similar to that of a complex forming agent in altering the distribution coefficient.

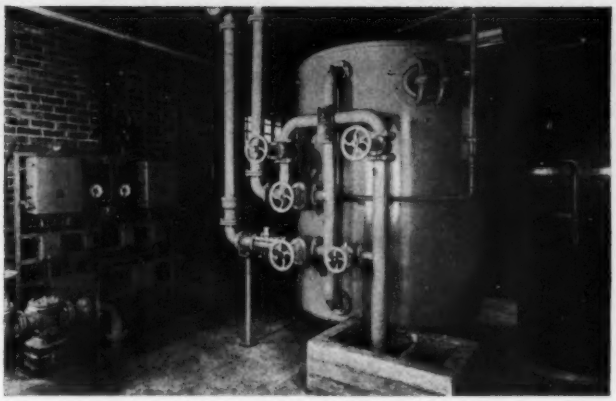
A quite different application involving non-aqueous solvents is the use[54] of cation exchangers to replace sulphuric acid for dehydrating cyclic alcohols.

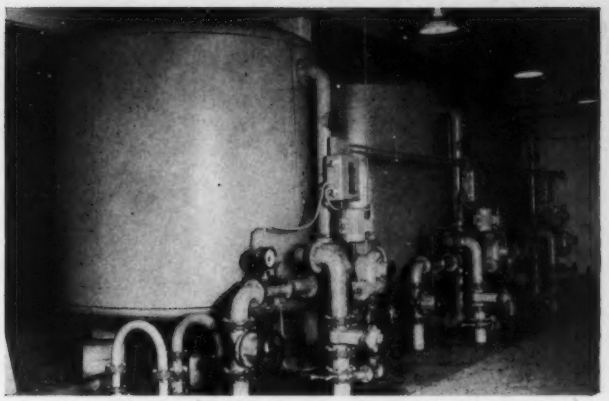
Continuous ion exchange

A recent review[3] discusses this subject generally and refers to publications available up to the end of 1953. The following section deals with more recent work.

At Stanford Research Institute, California, a research project on this topic has now been completed.[55] Laboratory counter-current equipment of both column and mixer-settler types has been successfully operated and design methods have been shown to give results at least of the right order. Design theory and laboratory work have also been described by Dickel and Böhm.[1]

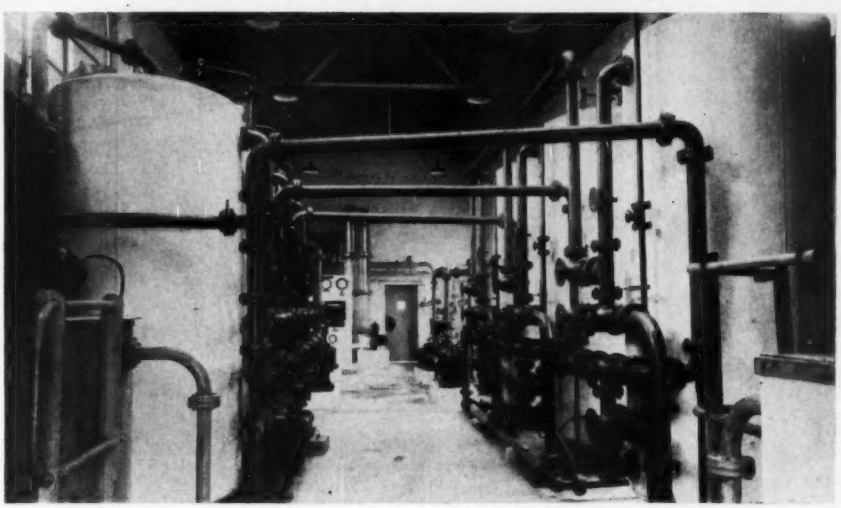
The Stanford workers recommended the vertical column with a downward-moving dense resin bed as the most suitable equipment for industrial counter-current ion exchange. They expected no serious difficulty in scaling up their laboratory columns, but some engineering problems do seem to exist. For example, with commercial resins, elutriation may occur at inconveniently low flow rates and any effort to prevent this by increasing the diameter of the particles would slow the exchange process undesirably. To solve this difficulty, Weiss *et al.*[56] have described methods of preparing adsorbents in which the active material is in the form of a thin porous shell coated on the outside of a denser inert core. In place of a vertical





[*Permutit Co., Ltd.*

Above, left: **Water used for wool scouring is treated by the Permutit manually-controlled ion-exchange water softener at the Mixenden Mills Ltd.** *Above, right:* **Fully-automatic ion-exchanger water softeners for water used in the manufacture of viscose rayon for Courtaulds Ltd.** *Below:* **The Permutit 'Deminrolit' water demineralising plant installed at I.C.I.'s Billingham works, for use in nylon manufacture.**



column the same workers have used[57] a swinging-sieve contactor, through which the solid phase passes in pulsed horizontal flow. Since this apparatus is based on well-established equipment used in ore-dressing work, it starts with some advantages.

Another contacting system makes use of endless belts which can be moved through adsorption, rinsing and regeneration tanks in series. One system[58] uses as belt a rubber tube filled with granular resin, while other workers[59] have endeavoured to make use of fabric belts into which exchange groups have been directly substituted, *e.g.* phosphorylated cottons.

A cost evaluation has been shown[60] to favour the counter-current over the fixed-bed method for commercial-scale ion-removal processes (*e.g.* demineralisation) For separation of similar ions no general comparison was possible owing to the variation of relative costs with the chemical system studied.

REFERENCES

[1]*Ann. New York Acad. Sci.*, 1953, **57,** Art. 3, 61-324.
[2]*Zeit. f. Elektrochem.*, 1953, **57,** 145-218.
[3] Ion Exchange and its Applications,' Supplement to *J. Appl. Chem.* (in press).
[4]C. W. Davies and G. D. Yeoman, *Trans. Far. Soc.*, 1953, **49,** 968.
[5]J. A. Faucher and H. C. Thomas, *J. Chem. Phys.*, 1954, **22,** 258.
[6]G. E. Boyd, B. A. Soldano and O. D. Bonner, *Ibid.*, 1954, **58,** 456.
[7]H. Deuel, K. Hutschneker and J. Solms, *Zeit. f. Elektrochem.*, 1953, **57,** 172.
[8]O. D. Bonner, *J. Phys. Chem.*, 1954, **58,** 318.
[9]N. Coleman and M. Harward, *J.A.C.S.*, 1953, **75,** 6045.
[10]W. H. Slabaugh, *J. Phys. Chem.*, 1954, **58,** 162.
[11]C. E. Marshall and W. J. Upchurch, *Ibid.*, 1953, **57,** 618.
[12]W. Sakai, *J. Electrochem. Soc. Japan*, 1953, **21,** 218 (*Chem. Abs.*, 1953, **47,** 11907).
[13]H. P. Gregor, J. Belle and R. A. Marais, *J.A.C.S.*, 1954, **76,** 1984.
[14]K. A. Kraus and G. E. Moore, *Ibid.*, 1953, **75,** 1457.
[15]S. Peterson and E. Gowen, *Ind. Eng. Chem.*, 1953, **45,** 2584.
[16]F. Kayser and J. M. Bloch, *Chimie et Industrie*, 1953, **69,** 1054.
[17]S. Goldstein, *Proc. Roy. Soc.*, 1953, **219A,** 151.
[18]A. Opler, *Ind. Eng. Chem.*, 1953, **45,** 2621.
[19]P. F. Hagerty and H. Bliss, *Ibid.*, 1253.
[20]E. R. Gilliland and R. F. Baddour, *Ibid.*, 330.
[21]J. F. Short, P. G. Smith and G. H. Twigg, *J. Appl. Chem.*, 1953, **3,** 198.
[22]P. W. Pfeiffer, *Chem. Eng. Sci.*, 1953, **2,** 45.
[23]J. A. Zeegers, *Ibid.*, 74.
[24]S. Waterai and S. Otake, *Chem. Eng. Japan*, 1953, **17,** 351 (*Chem. Abs.*, 1953, **47,** 11610).
[25]G. Dickel and A. Mayer, *Zeit. f. Elektrochem.*, 1953, **57,** 901.
[26]D. E. Conway, J. H. S. Green and D. Reichenberg, *Trans. Far. Soc.*, 1954, **50,** 511.
[27]D. R. Lewis, *Ind. Eng. Chem.*, 1953, **45,** 1782.
[28]G. E. Boyd and B. A. Soldano, *J.A.C.S.*, 1953, **75,** 6091.
[29]K. S. Spiegler and C. D. Coryell, *J. Phys. Chem.*, 1953, **57,** 687.
[30]A. Stach and M. Teichmüller, *Brennstoffchem.*, 1953, **34,** 275.
[31]Brit. Pat. 695,232.
[32]U.S. Pat. 2,661,337 (1953).
[33]W. Lautsch, G. Manecke and W. Broser, *Z. Naturforsch*, 1953, **86,** 232.
[34]G. C. Daul, J. M. Read and R. M. Rheinhardt, *Ind. Eng. Chem.*, 1954, **46,** 1042.
[35]R. H. Wiley, N. P. Smith and C. C. Ketterer, *J.A.C.S.*, 1954, **76,** 720.
[36]U.S. Pat. 2,631,999.
[37]K. W. Pepper, H. M. Paisley and M. A. Young, *J.A.C.S.*, 1953, 4097.
[38]Dutch Pat. 72,245.
[39]U.S. Pat. 2,645,627.
[40]H. P. Gregor, M. Taifer, L. Citarel and E. I. Becker, *Ind. Eng. Chem.*, 1952, **44,** 2834.
[41]M. Ezrin, J. H. Updegraff and N. G. Cassidy, *J.A.C.S.*, 1953, **75,** 1610.
[42]B. N. Airdrie, J. Bryant and J. V. P. Long, Chem. Res. Lab. Report AE/107.
[43]M. Honda and Y. Bizen, *J. Jap. Chem.*, 1953, **7,** 198 (*Chem. Abs.*, 1953, **47,** 10951).
[44]G. Scatchard, *J.A.C.S.*, 1953, **75,** 2883.
[45]M. J. R. Wyllie, *J. Phys. Chem.*, 1954, **58,** 67.
[46]T. R. E. Kressman, *J. Appl. Chem.*, 1954, **4,** 123.
[47]D. W. Simpson and R. M. Wheaton, *Chem. Eng. Prog.*, 1954, **50,** 45.
[48]F. S. Chance, G. E. Boyd and H. J. Garber, *Ind. Eng. Chem.*, 1953, **45,** 1671.
[49]G. W. Bodamer and R. Kunin, *Ibid.*, 2577.
[50]C. W. Keenan and W. J. McDowell, *J.A.C.S.*, 1953, **75,** 6348.
[51]T. Vermeulen and E. H. Huffman, *Ind. Eng. Chem.*, 1953, **45,** 1658.
[52]F. W. Burstall, P. J. Forrest, N. F. Kember and R. A. Wells, *Ibid.*, 1648.
[53]R. A. James and W. P. Bryan, *J.A.C.S.*, 1954, **76,** 1983.
[54]P. Mastagli, Z. Zafiriadis and E. Swistak, *C.R.*, 1953, **236,** 2325.
[55]N. K. Hiester and R. C. Phillips, U.S.A.E.C. Document AECU 2742.
[56]D. E. Weiss, *Aust. J. Appl. Sci.*, 1953, **4,** 510.
[57]E. A. Swinton and D. E. Weiss, *Ibid.*, 316.
[58]R. H. McCormack and J. F. Howard, *Chem. Eng. Prog.*, 1953, **49,** 404.
[59]W. A. Selke and C. H. Muendel, U.S.A.E.C. Document NYO 962.
[60]N. K. Hiester, R. K. Cohen and R. C. Phillips, *Ibid.* AECO 2739.

Construction of Aluminium Chemical Plant

THE range of aluminium-base materials is wide and selection of the most appropriate for a particular application is governed by factors such as strength, resistance to specific chemicals and ease of fabrication or welding. For chemical vessels, aluminium of 99.5% or 99.8% minimum purity is commonly used, but there are many applications for metal of higher purity (99.99% minimum) and commercial purity aluminium (99.0% minimum). For medium strength, suitable alloys are the aluminium-manganese (N3) or aluminium-magnesium (N4, N5, N6). All the above materials are of the non-heat-treated type and may be worked cold or hot. For structural sections, the heat-treatable, aluminium - magnesium - silicon alloy, H10, is used, or non-heat-treatable alloy N6. Composite materials, such as clad plate (HPC14 or HPC15) combine maximum strength with high corrosion resistance and have particular advantage for structural use.

Available forms and sizes

Aluminium alloys are available in a wide range of forms and sizes. All the common wrought forms are covered by British Standards 1470-77 : 1948-51. In particular, plate in aluminium and its alloys is now supplied up to 1 in. thickness and in sizes up to 30 ft. by 6 ft. wide, *e.g.* for very large vessels. Seamless tubes can be obtained up to 8 in. diameter, and, if needed for special purposes, extremely large diameter tubes can also be made by welding rolled-up sheet. Tube can also be extruded in very long lengths if so required and a great variety of other extruded sections, hollow and solid, is available.

Aluminium casting alloys are specified in B.S. 1490 : 1949. Where the requirements are not exacting, a general purpose casting alloy such as LM4 is used. Castings of great intricacy are made in amenable foundry alloys, such as LM6, which also has very good corrosion resistance: for the highest corrosion resistance the cast aluminium-magnesium alloy LM5 is recommended; less commonly, one of the grades of pure aluminium is used. Of recent years experience has been acquired in the manufacture of very large castings, up to 3 tons finished weight. Die-castings able to withstand pressures up to 2,000 p.s.i. or more can be made for high quality work such as valves and cocks.

Shaping

Sheet, plate and tubes of aluminium can be shaped with ease, provided—as with other metals—that the material is chosen with regard to temper so that after cold working in fabrication it will have the strength required for service. Sheet and plate are bent by the familiar means of bending rolls, bar folders, press brake, etc.

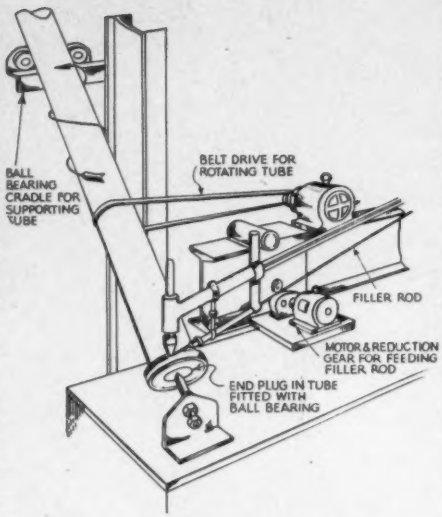

BALL BEARING CRADLE FOR SUPPORTING TUBE
BELT DRIVE FOR ROTATING TUBE
FILLER ROD
MOTOR & REDUCTION GEAR FOR FEEDING FILLER ROD
END PLUG IN TUBE FITTED WITH BALL BEARING

Diagram showing a method of adding weld metal to expanded ends of tubes. It is adaptable to the welding of flanges.

Due to the ease with which the material works, tubes are readily bent.

The ends of large cylindrical vessels are dished by pressing or spinning, or even by hand forging. Large spinnings up to 12ft. diameter can now be produced. Thick plate is readily flanged and pipe bends are made by argon-arc welding and by hot forging.

Pipe flanges in aluminium are either cast, welded or machined from solid plate; special shapes, such as covers or valves, may be cast or assembled by welding.

Aluminium tubes are expanded or rolled into aluminium headers in the normal manner, the header being grooved to give good location of the tube end. Sometimes the joint is sealed by welding round the edges.

For the insulation of aluminium structures, consideration should be given to aluminium foil, which is light, inexpensive and efficient for this purpose.

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Joining aluminium

Welding and brazing. Aluminium chemical plant has been successfully gas-welded for over 40 years; and in the hands of a skilled operator this method is capable of great exploitation for difficult welds. Much progress, however, has been made, and interest now centres in newer welding processes, such as metal arc welding and—more recently—argon-arc welding or consumable electrode welding. The latter methods have the great advantage of requiring no flux; consequently fillet welds and other joints—formerly not advised because flux residues could not be completely removed—can now be freely used.

It is becoming common practice to weld aluminium castings to wrought material. Thus, a cast manhole or inspection cover, valve or cock of suitable composition can be welded into a wrought aluminium vessel.

Pure aluminium and certain of the non-heat-treatable alloys can be brazed with the aid of aluminium-silicon brazing metal; torch brazing, furnace brazing, or flux dip brazing may be used, depending on the nature of the work. This process is applicable to small assemblies, particularly self-jigging assemblies, rather than to large constructions.

Riveting. The scope of this process has now been extended to large joints: structures and components requiring rivets up to $\frac{7}{8}$ in. diameter can now be riveted with the equipment for driving steel rivets. This development is of importance for structural items such as pipe bridges and roof trusses.

Surface treatment

In most circumstances the inert oxide film on aluminium provides adequate resistance to chemical attack and no applied finish is required. Anodising is sometimes advantageous where very slight attack on the metal may be expected from certain waters or other substances; a decision has to be based, however, on the merits of each individual case. Chemical treatment of the surface, such as by the M.B.V. or *Alocrom* processes, may offer slight advantages in improved resistance to specific chemicals. These treatments, however, are more useful in providing a very good key for the adhesion of applied finishes such as lacquers, paint, etc., where these are required.

Maintenance

External surfaces of aluminium plant exposed to the weather do not usually need paint for protection, but where paint is used its life tends to be longer on aluminium than on steel. Paint schemes for aluminium usually include a zinc-chromate primer which has an inhibitive action in protecting the aluminium, followed by one or more finishing coats compatible with the primer.

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Thermal Conductivity of Organic Liquids

By O. P. Kharbanda, M.Sc., D.Ch.E.

(Research Department, Simon-Carves Ltd., Stockport)

THERMAL conductivity is one of the fundamental properties of a substance, and a knowledge of this property is required in design calculations involving heat and mass transfer operations. The published reliable experimental data on thermal conductivity of organic liquids are presented here as a function of temperature, in the form of easy-to-use nomograms.

The experimental data on the thermal conductivity of liquids are quite abundant, but not always reliable. For the same liquid, results obtained by different workers, or by a different method, often differ to a considerable degree. Most of the early investigators used a system of horizontal surface heated upwards. Thick liquid films were employed[1] and this caused the presence of convection currents. Conduction was, therefore, not the sole process for heat transfer, thus giving erroneous and often inconsistent results for thermal conductivity.

In order to eliminate the convection currents, thin films were later used and some reliable results obtained. The use of thin films, however, introduces an additional error, for it is difficult to measure the thickness of films accurately when of the order of a few hundredths of an inch. After a careful study and some preliminary work at the Engineering Experiment Station of the Louisiana State University, it has recently been shown[2] that convection effects can be eliminated, even in thick films (of the order of 1 to 2 in.), provided they are heated downwards. This investigation is still under way and its further results are awaited with interest.

The first part[3] of this investigation was a literature survey of the thermal conductivity of liquids. This survey reviewed the experimental methods of measurement used by previous workers and also presented a summary of their results. The reliability of these results was evaluated by considering:

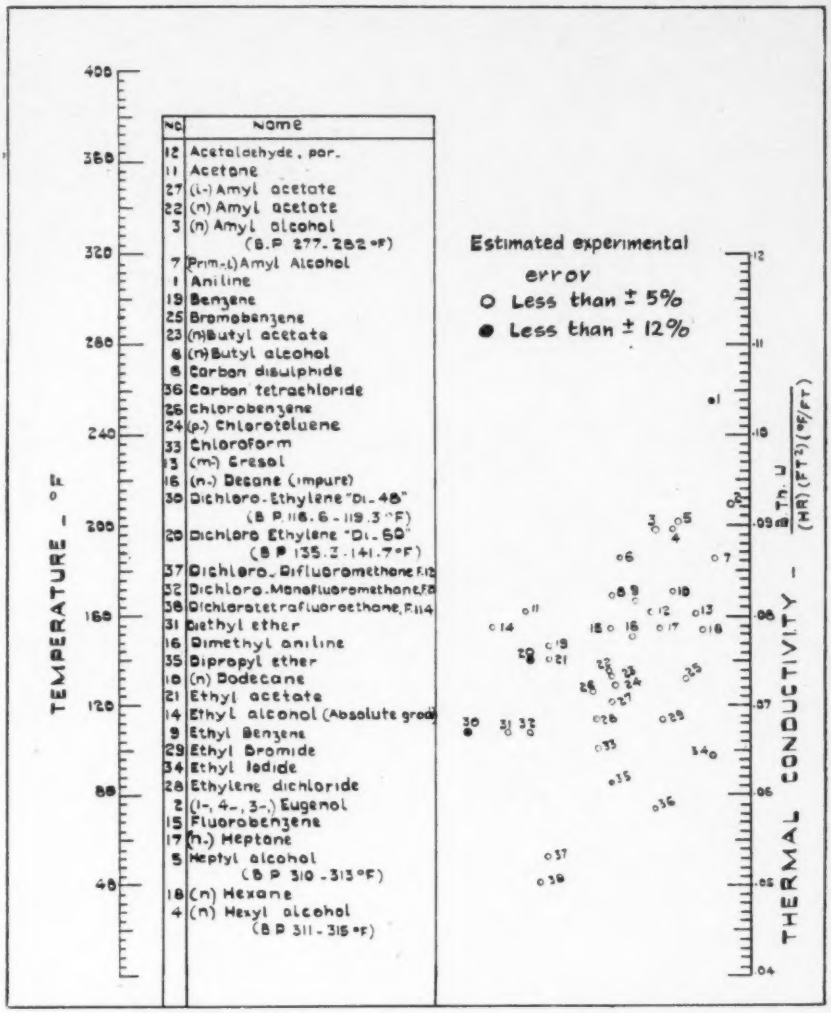
(*a*) whether the conditions of pure conduction were satisfied,
(*b*) accuracy of measurement of the various quantities involved,
(*c*) corrections, if any, for the heat losses by convection, and radiation, and
(*d*) consistency of the data.

Based on these factors, the following reliability scale was established:

Estimated experimental error	*Rating*
Less than ±2%	Excellent
Less than ±5%	Very good
Less than ±12%	Good
Greater than ±12%	Average
Unreliable	Poor

None of the experimental results on thermal conductivity of organic liquids are rated as ' excellent,' possibly because of the difficulties mentioned above—namely the undesired convection effects in thick films or the error involved in measuring the thickness of very thin films. The results rated as ' average ' or ' poor ' are not considered to be suitable for use in good engineering design work, and those with a rating of ' very good ' and ' good ' seem satisfactory for most purposes. The survey[3] listed, for each liquid:

(*a*) the range of temperatures investigated,
(*b*) thermal conductivity at the lowest temperature,
(*c*) temperature coefficient of thermal conductivity, and
(*d*) the purity, or some physical properties, of the liquid when reported by the original worker.



Nomogram No. 1.

For convenience in design calculations, it is desirable to have an easily accessible source for thermal conductivities of liquids at various temperatures. The reliable experimental results are therefore presented, as a function of temperature, in the accompanying nomograms. Nomograms Nos. 1 and 2 relate to pure organic liquids and No. 3 pertains to some miscellaneous liquids of industrial importance. The results of other investigations relating to the thermal conductivity of tetraoctyl silicate,[4] castor oil and a hydraulic fluid,[5] as well as furfural[6] have also been included in this presentation.

Mason[7] has recently reported thermal conductivity data for several organic

Table 1. Thermal Conductivity of Liquids having Positive Temperature Coefficient

Name	Thermal conductivity at 86°F.	Thermal conductivity at 212°F.	Estimated error (%) Less than	Ref.
p-Cymene	0.0779	0.0800	±5	3
Ethylene glycol	0.1515	0.1578	±5	3
Furfural	0.093	0.1045	±2	6
Glycerol	0.1723	0.203	±5	3
Mesitylene	0.079	0.0800	±5	3
Chlorinated diphenyl (MW = 257.4)	0.0711	0.0726	±5	3
Chlorinated diphenyl (MW = 292.8)	0.0680	0.0695	±5	3

Table 2. Thermal Conductivity of Liquids at one Temperature

Name	Refractive index at 68°F.	Temperature, °F.	k	Estimated error (%) Less than	Ref.
Acetaldehyde	—	69.8	0.0990	±12	3
Acetic acid (97%)	—	72.6	0.2250	± 5	3
Acetic anhydride	1.3909	69.8	0.1280	±12	3
Allyl isothiocyanate	1.5204	71.6	0.1117	±12	3
Amyl bromide	—	64.4	0.0569	± 5	3
Methyl aniline	1.5714	70.5	0.1070	±12	3
Pentamethylene imine	1.4549	71.6	0.1043	±12	3
Pheylhydrazine	—	69.8	0.0998	± 5	3
Gasoline No. 1	—	86.0	0.0774	± 5	3
Gasoline No. 2	—	86.0	0.0770	± 5	3
Poppy oil	—	39.2	0.0978	±12	3
Vaseline	—	59.0	0.1065	±12	3
Castor oil	—	68.0	0.1030	—	5
D.T.D. 44D (hydraulic fluid)	—	59.0	0.0756	—	5

liquids in the temperature range 32 to 212°F. Materials of high purity were used in this careful experimental work. A total of 21 liquids were investigated and the results are claimed to be reliable to within 2%. For about half of these liquids no reliable results had been reported before. The entire results of this investigation have been used in preference to previously published values. Data on the thermal conductivity of some high-molecular-weight organic compounds have also been published.[8] These liquids are not considered of sufficient importance for inclusion in the accompanying nomograms.

The only satisfactory theoretical equation for thermal conductivity of liquids has been derived by Bridgman:[9]

$$k = 3\,\frac{Ro}{N}\,\frac{v}{D^2}$$

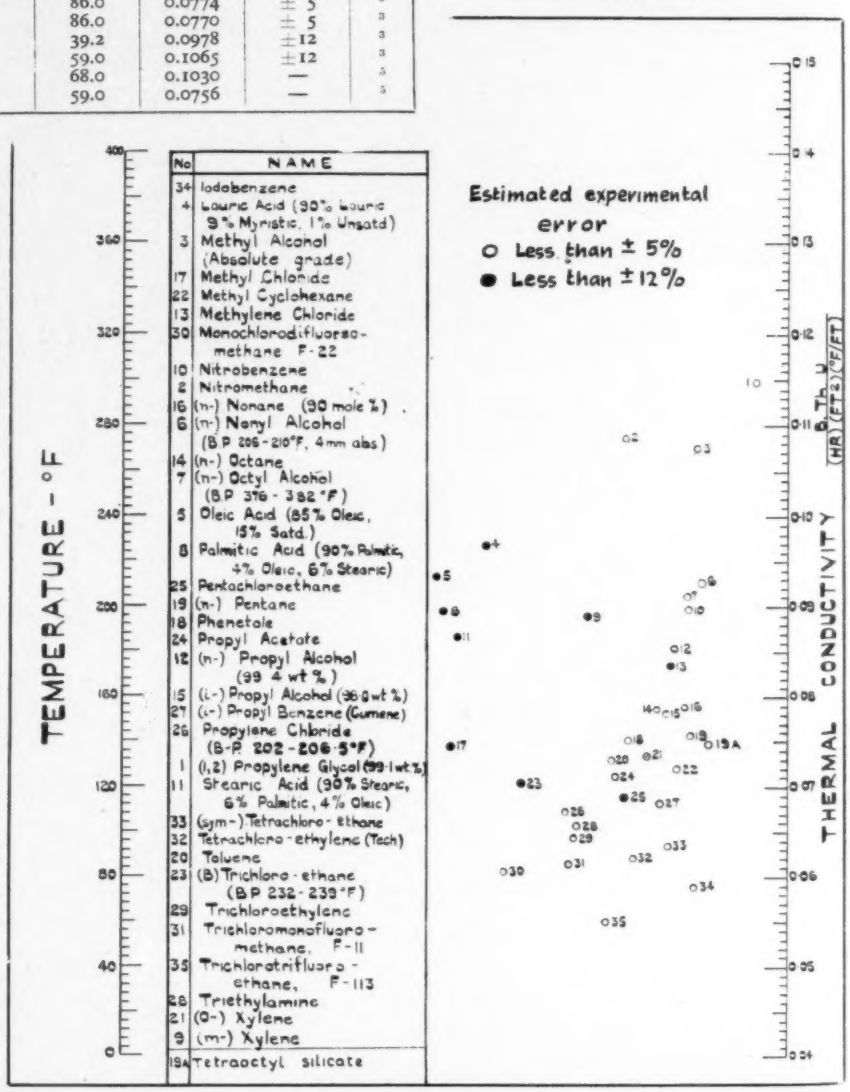
where k = thermal conductivity of the liquid, Ro = universal gas constant, N = Avogadros' number, v = the velocity of sound in liquid and D = the mean distance of the centres of adjacent molecules, under the assumption that these are arranged in simple cubical array.

This equation predicts values for thermal conductivity which are at least of the correct magnitude. This is remarkable,[1] considering that no empirical constant is used. For organic liquids, v decreases and D increases with rising temperature so that k should decrease with rising temperature. This is confirmed by data on most organic liquids. In drawing the accompanying nomograms, the usual[3] linear variation of thermal conductivity with temperature is assumed. It must be pointed out that, except for few liquids, the experimental thermal conductivity data rarely extend to temperatures above 212°F. The extrapolation to higher temperatures is, therefore, doubtful.

For few liquids, notably of the polyhydroxy type, thermal conductivity seems to increase with temperature. Also, water, as usual, seems to form a class by itself—its thermal conductivity first increases with temperature reaching a maximum value at 120°C. and then decreases with further increase in temperature. The data for organic compounds having a positive temperature coefficient are presented in Table 1. In addition, for several other liquids, reliable thermal conductivity data are available only at one temperature. This information is not sufficient for inclusion in the nomograms. However, for sake of completeness, such data are presented in Table 2.

All the data presented here refers to a pressure of 1 atm. The thermal conduc-

Nomogram No. 2.

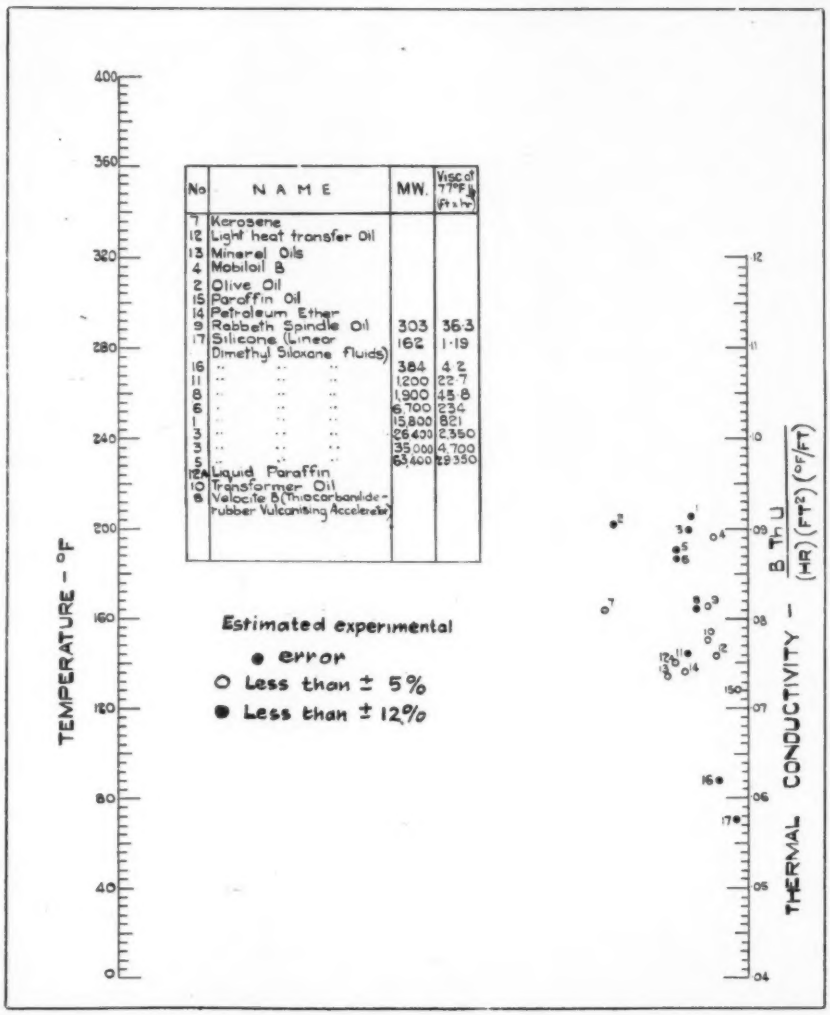


tivity of liquids increases only slightly with pressure—an increase of the order of 10 to 15% when the liquid is compressed to 2,000 atm.[1] For moderate pressures, therefore, it appears safe to use the values obtained from these nomograms.

BIBLIOGRAPHY

[1]W. H. McAdams, 'Heat Transmission,' McGraw-Hill, New York, 1942.
[2]B. C. Sakiadis and J. Coates, 'Studies of Thermal Conductivity of Liquids, Part II —An investigation of factors affecting the design of a liquid thermoconductrimetric apparatus,' Bull. No. 35, Eng. Expt. Station, Louisiana State University, 1953.
[3]*Idem*, 'A Literature Survey of Thermal Conductivity of Liquids,' *Ibid.* No. 34, 1952.
[4]S. Baxter, H. A. Vodden and S. Davies, *J. appl. Chem.*, 1953, **3**, 477.
[5]A. E. Bingham, *Engineering*, 1952, **173**, 254.
[6]A. F. Schmidt and B. H. Spurlock, Jun., *Trans. Am. Soc. Mech. Engrs.*, 1954, **76**, 823.
[7]H. L. Mason, *Ibid.*, 1954, **76**, 817.
[8]M. F. Dick and D. W. McCready, *Ibid.*, 1954, **76**, 831.
[9]P. W. Bridgman, *Proc. Nat. Acad. Sciences*, 1923, **9**, 341.

Nomogram No. 3.



Fertilisers Without Sulphuric Acid

THE total consumption of sulphuric acid in 1955 by O.E.E.C. countries has been estimated to be about 12.6 million tons, 4 million of which will be required for superphosphate manufacture. At this figure, however, the deficit will be 1.6 million tons or about 13% of estimated requirements.

In 1951-52, 54% of all sulphuric acid consumed was for the manufacture of fertilisers—superphosphate and sulphate of ammonia—and the greatest amount was for superphosphate. It is essential for the success of the agricultural expansion programme that increasing quantities of phosphate fertilisers should be used, and demand will probably increase annually by 10½%. The deficit is therefore likely to continue unless energetic steps are taken to conserve acid.

Many types of phosphate fertilisers for which no sulphuric acid is used have been developed during the last few years. Other processes are also known which require less sulphuric acid than is used for superphosphate manufacture. The principal methods used in O.E.E.C. countries for the manufacture of alternative phosphate fertilisers are outlined in the report, recently published, of a working party appointed to study this question by the O.E.E.C. Sub-Committee for Scientific Research and Technical Development.

Saving of Sulphuric Acid

Process	*Sulphuric acid saved per ton of soluble P_2O_5 (tons 100% H_2SO_4)*	*Nitrogen required per ton of soluble P_2O_5*	
		Ammoniacal	*Nitric*
Nitric	7.7	0.5	1.0
Sulpho-nitric ..	5	0.5	0.5
Phospho-nitric:			
Dry	6	0.5	0.5
Wet	4.6	0.5	0.5
Ammonium phosphate:			
Dry	3.2 (mono)	0.2	—
	3.9 (di)	0.4	—
Wet ..	About 1 (mono)	0.2	—
	About 1 (di)	0.4	—
Dicalcium phosphate ..	0.5	—	—
Thermal ..	2.5	—	—
Basic	2.5	—	—
Ground ..	2.5	—	—

Some of the newer processes use nitric acid in place of sulphuric acid. Before such processes can be used on an extensive scale, consideration would have to be given to the capacity for nitrogen fixation in each country.

Other processes have been developed based on the reduction of phosphate rock to elemental phosphorus by the electric furnace process. These processes, however, require cheap electric power and can only be economical where this is available.

During recent years, the introduction of fertilisers based on nitric acid has meant that both nitrogen and phosphorus are available in the final product. By the addition of potassium salts, these binary fertilisers become complete N.P.K. fertilisers.

The processes discussed in the report are considered under the headings of 'complex' fertilisers, dicalcium phosphate, ammonium phosphates, ammoniated superphosphate, thermal processes, and ground rock phosphate. The accompanying table indicates the quantity of sulphuric acid, per ton of soluble P_2O_5, in the product which is saved in the manufacture of some different types of alternative phosphate fertilisers. Where 'complex' fertilisers are produced containing both nitrogen and phosphate the table includes the sulphuric acid which would have been used for the corresponding amount of ammonium sulphate, as well as the amount of nitrogen required.

Chemical, Chemical Engineering and Plastics Exhibition in Paris

THE 3rd Salon de la Chimie et des Matières Plastiques is being held in Paris from the 3rd to the 12th of this month. The Salons de la Chimie are a recent creation; it was in November 1951 that the first one opened its doors. The success of this exhibition led to the organising of a second, which was held 18 months afterwards, in June 1953. This second exhibition, which included a plastics group, achieved even greater success than the preceding one.

The third exhibition, featured in the following pages, shows promise of attracting still more interest. As well as the exhibition itself, a series of technical meetings has been organised at which the subjects to be discussed include vacuum technique, chromatography and ion exchange, applications of microscopy in chemistry, antifouling paints, electronic techniques in the service of chemistry, control and regulation systems in sugar refineries, recent developments in plastics, and corrosion.

The scope of the exhibition has been increased considerably and exhibits are grouped under five classifications: (a) laboratory equipment, optical and scientific instruments, and apparatus for measurement and control; (b) chemical engineering, including both general and specialised plant; (c) chemical products and raw materials for the chemical, paint, oils and fats, pharmaceutical, rubber, metallurgical and other industries; (d) plastics industry, including raw materials, intermediates, and industrial plant made of plastics as well as manufactured goods; and (e) organisation, including scientific and industrial management, scientific institutions, research laboratories, new inventions, standardisation, documentation, publishing, productivity, etc.

Of these exhibits we are able to describe and illustrate only a selection, displayed on only some of the stands. However, with the co-operation we have received from exhibitors, we have been able, despite the language difficulty, to make our survey fairly representative and, we think, sufficiently comprehensive to hold something of interest for all in the chemical, plastics and associated industries.

FRENCH CHEMICAL INDUSTRY'S EXPANSION PLANS

BY way of introduction to our survey of the third Salon de la Chimie, a brief note of current French plans for the expansion and re-equipment of the chemical industry will not be out of place. Details have been given by M. Etienne Hirsch, who is Commissioner-General of the second Plan de Modernisation et d'Equipement. Within the framework of this plan for stepping up French industrial production generally, the chemical industry is to receive a capital allocation of about £200 million, spread over five years.

Under the plan for industry as a whole, the national income is to be raised by 25% compared with 1952, agricultural production by 20%, industrial production by 25 to 30% and building production by 60%. It is proposed to achieve this ambitious aim by the development of technological research, the introduction of modern production methods, standardisation of manufacturing processes, and increased specialisation by individual manufacturers.

For the chemical industry, the accent lies on the modernisation of existing installations and bringing down costs; new installations are not contemplated except for certain new products. It is also planned to make the French industry more competitive, after a period of stagnation caused by the war and its aftermath.

Particular attention is being paid to the production of sulphuric acid, ammonia, chlorine, calcium carbide, sodium products and fertilisers. In the case of sulphuric acid production, there is reason to believe that the demands of the next few years are adequately covered. Nevertheless, it is planned to increase production in new or modernised factories situated closer to consumer areas, and to convert a number of installations using the chamber process to the contact process.

Chlorine production is to be stepped up by 20% to a level of 177,000 tons p.a.; calcium carbide production will be increased to over 300,000 tons.

For the production of fertilisers, the targets have been fixed by a mixed committee of chemical and agricultural experts. There is going to be a shift of emphasis from ammoniacal to ammoniacal-nitric types; a decision concerning the extension of production of ammoniacal fertilisers has been deferred to 1956.

Other branches of the French chemical industry due to expand include the phenol and acetone industries, and also the plastics industries (especially polyvinyl products). Production of plastics by 1957 is scheduled to cover twice the present demand.

In addition, the introduction of a number of processes new to France is contemplated, including the production of hydrocyanic acid, acrylic nitrile, ethylmethyl ketone, methylene chloride, styrene and butyl rubber. These products have been carefully selected having regard to the availability of raw materials, suitable labour, etc. New branches of the chemical industry are also likely to be stimulated by the discovery of new sources of natural gas.

The capital required for the expansion and re-equipment of the chemical industry will largely be in the form of long-term loans, partly financed by savings funds.

The programme of action embraces, *inter alia*, the systematic expansion of research work and effectual liaison with research institutes engaged in related fields such as work on macromolecules, catalytic phenomena, etc. The training of qualified chemical engineers is to be encouraged, and the study of new and more efficient production methods to be promoted.

REVIEW OF THE 3RD SALON DE LA CHIMIE

A SELECTION OF EXHIBITS TO BE SEEN ON SOME OF THE STANDS

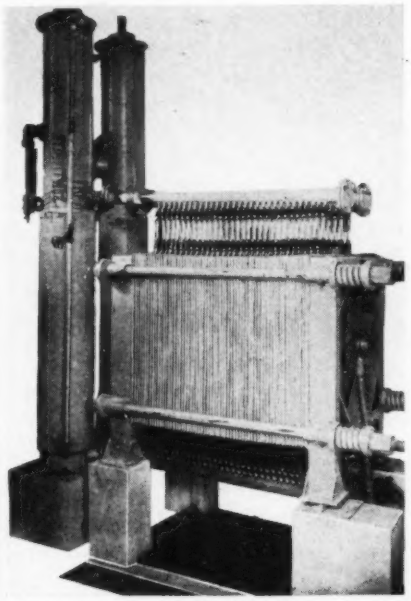
Société **Adsul,** 22 rue Pierre Nicole, Paris V. Suppliers of laboratory equipment. This company is showing *p*H meters and titrimeters. (Stand No. 131-133, Lavoisier passage.)

Alkan & Sinay, 59 Boulevard de Belleville, Paris XI. Suppliers of electrical apparatus. Exhibits include process timers, interval timers, time delay relays and mercury switches. (Stand No. 304, de Moissan passage.)

A.M.I.L. (Appareillage-Matériel Industriel et de Laboratoire), 8-bis, rue Cherbuliez, Paris XVII, engage in the design and construction of apparatus for industrial and laboratory applications. Their exhibits include a mixer-calender and ageing apparatus.

ARCA, 56 rue de l'Eglise, Paris XV. The Société des Regulateurs Universels ARCA, which is the French branch of the ARCA companies established in Britain and elsewhere, displays some automatic controllers which are at present manufactured only in France. They measure the controlled variable electrically and then act on the controlling component pneumatically. This, the makers claim, allows the accuracy of an electrical measurement to be combined with the advantages of an air-operated control. Two applications of this electro-pneumatic principle will be demonstrated. (Stand No. 52A.)

Etablissements **Auguste & Des Moutis,** 37 rue Saint-Blaise, Paris XX. Builders of emulsifying and homogenising machines, beater-mixers and semi-automatic tube-filling machines. The A.L.M. range of emulsifying and homogenising machines are for use in the pharmaceutical, chemical and cosmetics industries, and for high- or low-pressure treatment of liquid, semi-liquid or pasty materials. Output varies from 10 to 500 kg. for a minimum of 0.33 to 5 cv. (Stand No. 402-404, Reaumur passage.)



Electrolyser for production of oxygen and hydrogen, exhibited by Moritz.

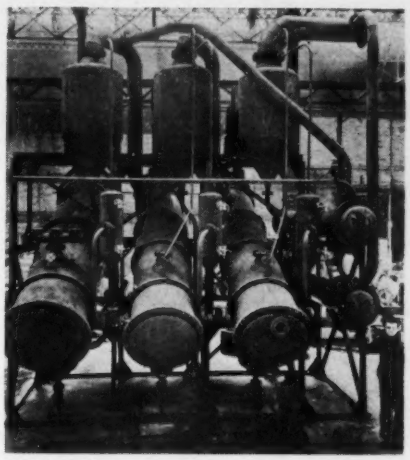
Société **Beri,** 141 rue Vercingeterix, Paris XIV. Measuring and controlling instruments. This company's display includes indicating, recording and controlling flow meters for all liquids; manometers, pressure and vacuum gauges reading from 3 mm. head of water up to the highest pressures; gauges and recorders for absolute vacuum; and manometers with inclined tubes made of *Plexiglass*.

Speed reduction gear for mixing and agitation, exhibited by Cidma.

Remote-indicating dilation thermometers, and liquid remote-indicating and recording liquid-level gauges for open or closed tanks under pressure or in gas holders are also shown, while further exhibits include recording densimeters for gases and liquids and a standardising station for flow meters and manometers. (Stands Nos. 136, 138, 201 and 203, Lavoisier and Gay-Lussac passages.)

S.A.I.M.P.J. **Bonis,** 9 rue de Clignancourt, Paris XVIII. This company supply apparatus in plastic materials, including containers and pipes for acids and other corrosive products. They also specialise in ventilation and pumping problems, laboratory installations, etc. Their exhibits include ventilators of PVC. (Stand No. 69, Pierre and Marie Curie passage.)

Brewer Frères, 76 Boulevard Saint-Germain, Paris V, are exhibiting a range of laboratory apparatus including balances of all types and various electric heating accessories. The latter include heating mantles for flasks from 250 cc. to 10 l. capacity, consisting of two separate elements placed inside a parabolic reflector of polished aluminium and controlled by switches and regulators. The upper part of the flask is surrounded by a hemispherical reflector in two sections, which can readily be removed for manipulation of the flask so that the maximum heating efficiency of the infra-red rays is obtained. Electric hotplates are also being shown which consist of armoured resistances (1,300 w.) embedded in sheets of a hard aluminium alloy and controlled by a regulator to provide temperatures up to 450°C.



Triple-effect evaporator for concentration of hardening solution, marketed by Prache & Bouillon.

Société le **Carbone-Lorraine,** 45 rue des Acacias, Paris XVII, are exhibiting *Polybloc* graphite heat exchangers, bundle or tubular heat exchangers, parts of absorption towers and scrubbers, and piping, all in impervious graphite. The cylindrical graphite heat exchanger consists of a pile of impermeable monolithic graphite rings. Each ring comprises two sets of passages, one set parallel to the axis and the second set arranged radially. One of the heat-exchange fluids passes through the axial passages, while the second fluid circulates through the radial passages. Peripheral obstruction rings and central discs are provided alternatingly at the joints between the blocks, and this ensures sinuous flow of the radial fluid. Any number of blocks can be used to produce a given heat-exchange area.

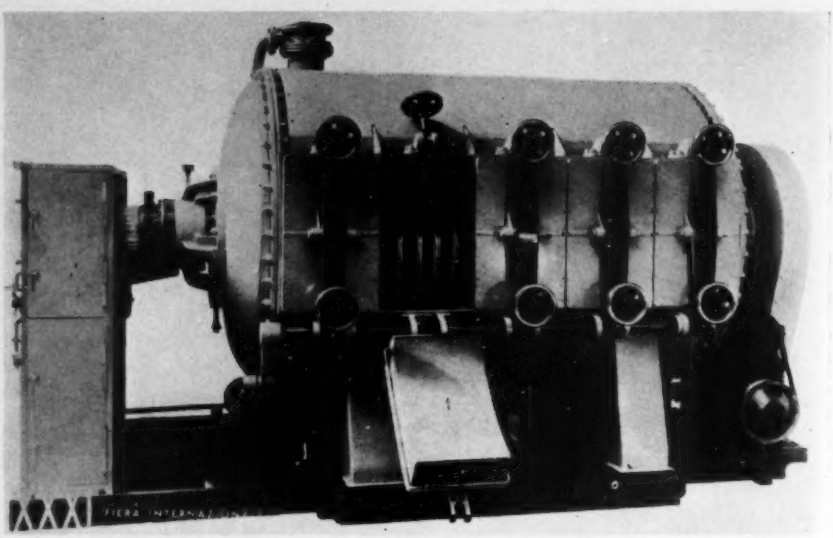
Cameca (Compagnie Radio-Cinema), 103 Boulevard Saint Denis, Courbevoie (Seine), exhibit their automatic *Spectro-Lecteur*, which is a direct and instantaneous reading instrument for spectrochemical analysis in metallurgy. It is designed for

attachment to the medium dispersion quartz spectrograph manufactured by Jobin & Yvon. The makers claim that an unskilled operator without any special qualifications is able, with a few days' training, to learn the essentials and manipulation of the apparatus, and that it can be used in every field covered by spectrochemical instruments using the photographic plate. The field of applications covers a range of alloys including aluminium, magnesium, zinc, copper, iron and lead alloys as well as miscellaneous materials such as soils, ceramics, glasses, slags and cements. (Stand No. 232-234, J. B. Dumas passage.)

Filtre **Chamberland Système Pasteur**, 80-bis rue Dutot, Paris XV, are exhibiting a range of their filter candles, made of porous porcelain, which are used for sterilisation and for micro-filtration. The makers state that the pore size and permeability can be modified to suit a large number of applications, and that one of the great advantages of the system is the ease with which organic contamination or clogging can be removed, either by heating or by the action of the chemicals, as the candles are practically indestructible. (Stand No. 36, Branly passage.)

CIDMA, 175-179 Boulevard Saint-Denis, Courbevoie (Seine). This firm are exhibiting a range of fixed and infinitely variable vertical speed reduction gears, transmitting from ½ to 25 h.p., for mixing and agitation. Features include co-axial motor with slow-speed shaft, precision gears made of Ni-Cr steel, epicyclic slow-speed satellite gears mounted on roller bearings, long guide sleeves on the slow-speed shaft with conical roller bearings, and oil sump below gears. The makers claim that this type of reducing gear can transmit a high vertical torque and can be attached to a very long secondary shaft without the necessity for intermediate or end supports. Applications include chemical industry, paints and varnishes, soap, oil mills, dairy and foodstuffs, pharmaceutical products, sugar and jam, confectionery, chocolate, bakery and biscuit manufacture. (Stand No. 312, Henri Moissan passage.)

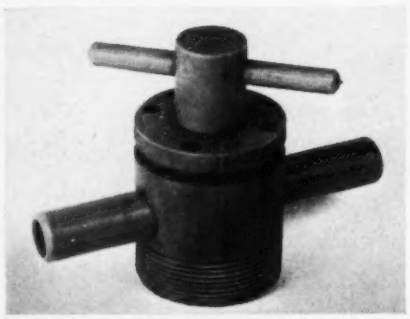
Société des Compresseurs a Membrane **Corblin**, 78-80 Boulevard Saint Marcel, Paris XV. This firm are displaying their new diaphragm compressor, which has applications in the chemical and other industries and is suitable for refrigeration installations where ammonia, carbonic acid gas or freon is used. The makers give the following description. The Corblin diaphragm compressor is essentially made up of two cylindrical plates with conically ground-out bearing surfaces held together by bolts which clamp a flexible metal diaphragm. One of the plates is perforated with holes through which the double-cone chamber communicates with a pump; the other plate bears the valve boxes for gas suction and discharge. A piston acts on the oil with which the pump barrel is filled, thus giving the diaphragm its oscillating motion and hence gas suction and delivery. Since the piston works in oil and since the diaphragm separates the gas from the oil completely, the compressor operates without stuffing box; this, added to maximum volume output ensured by the small compensation pump, allows the compressor to work with the minimum amount of motive power. (Stand No. 118A, Ste-Claire Deville passage.)



A new design of filter, with hydraulic washing device, being displayed by Filtres-Philippe.

Damac (Développement et Application des Techniques et Matériaux Anti-Corrosion), 8 rue du Debarcadere, Parix XVII. This company describes its exhibits as special pastes for pickling and passivating the stainless steels, a reagent for indentifying molybdenum in steels and the 'Electro-Test' for identifying various steels and alloys. (Ugine-Geugnon Stand No. 95 and Stinox stand No. 254, J. B. Dumas passage.)

Danto-Rogeat & Cie, 33-39 rue des Culattes, Lyon, are exhibiting enamelled cast-iron and glass-lined steel plant for the chemical industry, and heat exchangers. (Stands Nos. 161 and 163, Lavoisier passage.)



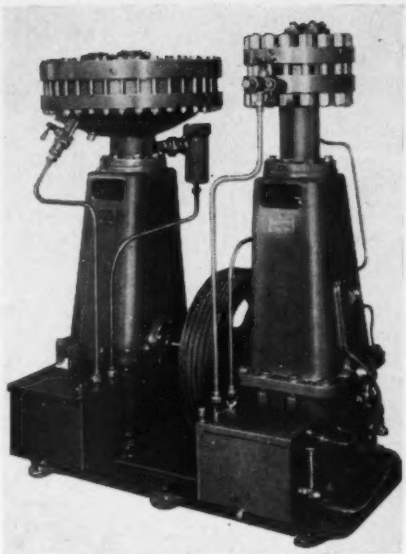
This valve in PVC is exhibited by Manufacture Francaise de Vides-Touries Automatiques, along with other equipment for handling acids and corrosive chemicals.

de Dietrich & Cie, Niederbronn-les-Bains, Bas-Rhin, France. Glass- and rubber-lined cast iron and steel equipment for the chemical, pharmaceutical and allied industries. Exhibits include reactors, valves in glassed cast iron and steel, and condensers in glass, rubber and graphite. (Stand No. 67, Henri Moisson, Pierre et Marie Curie, Marcelin Berthelot passages.)

Société **d'Electrochemie, d'Electrometallurgie & des Acières Electriques d'Ugine**, 10 rue du Général Foy, Paris VIII. Makers of chemicals, aluminium, special steels, etc. Exhibits include: *Steels* —high tensile and wear-resisting manganese steels; special constructional steels; tool steels; steel for ball and roller bearings; stainless and heat-resisting steels; rolled, drawn, drawn wire, annealed and treated steels; forgings and castings. *Chemicals* (to name only some)—chlorine, liquid; hydrochloric acid; magnesium chloride, anhydrous; antimony trichloride; sodium hypochlorite; sodium chlorite; potassium chlorate, etc.; monochlorbenzene; *Ortosol* (ortho-dichlorbenzene); *Electrophenyl* (various grades of chlorinated diphenyl); *Pyralenes* (mixtures based on chlorinated diphenyl and trichlorbenzene); carbon tetrachloride; chloral anhydride; *Electrogum* chlorinated rubber; sodium peroxide; caustic soda (electrolytic, fused); caustic soda liquor; sodium aluminate; sodium silicate; fluorine; hydrofluoric acid; boron trifluoride, etc.; cryolith; chiolite; lithium; ammonium; barium and zinc fluorides; fluoboric acid; fluoboric acid salts; sodium fluosilicate; zinc and magnesium complex fluosilicates; trichlor monofluoromethane, etc.; hydrogen peroxide; sodium peroxide; urea peroxide; sodium perborate; ammonium persulphate; potassium persulphate; potassium cyanide; sodium cyanide, etc.; acetone cyanhydrin; salts for heat treatment and surface treatment of metals;

alumium hydroxide; alumium oxide; activated aluminium oxides; bauxite; artificial jewels and stones; sodium aluminate; aluminium sulphate; potassium alum; ammonium alum; common alum; vanadic acid; ammonia, anhydrous liquid; diphenyl; compressed, liquid and dissolved gases (air, oxygen, nitrogen and acetylene); ammonium meta-vanadite; oxides of iron (synthetic); sodium, metallic; calcium, metallic; cobalt, metal; ferro-boron; cerium, metal; ferro-cerium; cero-magnesium; ferro-vanadium.

Société Anonyme Commerciale des **Filtres Philippe** are displaying a new design of rotary-disc pressure filter resulting from the combined studies of their engineers and those of the Italian Officine Mechaniche di Savona in Genoa. The filter is used in the sugar industry and has applications in the chemical industry. The discs are segmented in six or eight parts, each segment being easily dismounted. The declogging of the filter can be made by several means according to the nature of the sediment and whether it is to be recovered. One way is by washing the discs by means of high-pressure liquid jets during the rotation of the discs, the jets being provided by nozzles set on one or several pipes inside the filter shell. Another means employs a series of special scrapers. This company is also showing a fully automatic filter developed by R. P. Adams & Co., of U.S.A., and with two main applications: the continuous filtration of raw water, and the continuous filtration of ammonia liquor in the coke oven industry, where it produces a continuous stream of filtered solution with automatic backwash of solids to sump.



A two-stage oxygen compressor (3,550 p.s.i.) being exhibited by Corblin.

Etablissements **Francel**, 34 rue de la Victoire, Paris. The universal programme controller displayed by this company is based on the Francel relay modulator, which is actuated by compressed air and does not require a special cam for each programme of operations. It is only necessary to draw a diagram on the paper chart of the sequence of the periods and values of the units required. The paper is then cut along the line of the tracing and is placed on the drum of the timing mechanism. A pneumatic 'feeler' then closely follows the cut edge of the paper, but without actual contact, and transmits orders to the servo-motor which controls the regulating valve by means of a compressed-air modulating relay.

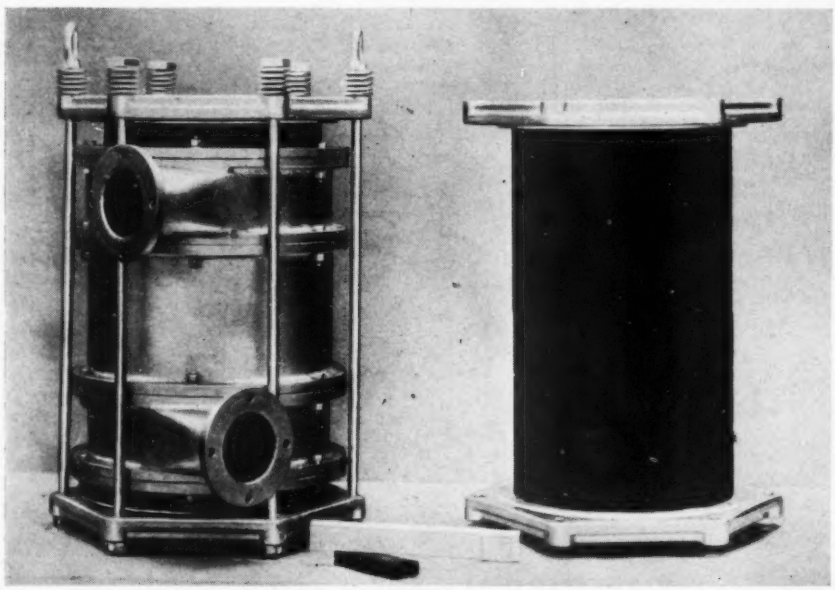
Among other exhibits are the Adamel-Francel continuous automatic heat-flow controller and also aeroscopes which are not meant to be used exclusively for laboratory work but for use in industrial works, and are claimed to give, in 2 min., densities of any liquids with an accuracy up to the fifth decimal.

Getting-Jonas-Titan, 29-bis, rue d'Astorg, Paris VIII, are displaying polythene pipes and permanent magnets. (Stand No. 283, Marcelin Berthelot passage.)

Cie **Gohin-Poulenc**, 48 rue de la Bienfaisance, Paris VIII, are exhibiting air and gas driers. (Stand No. 244, J. B. Dumas passage.)

Broyeurs **Gondard**, 48 rue des Bergers, Paris XV, are exhibiting laboratory grinding mills, granulators, industrial hammer mills, horizontal mixers and automatic control apparatus for conveyors, etc. The laboratory hammer mills are suitable for a wide range of vegetable and mineral materials and require from ½ to 2 h.p. at 6,000 r.p.m. The body is of cast steel and the hammers are of special steel or chromium plated. The machine can be taken down and re-assembled after cleaning without the use of tools. Gondard granulators are supplied with or without air separation systems and are used for plastics, cork, slate and chemicals. The machine can be adjusted to give granules of various sizes. The power required is from 4 to 6 h.p. and typical outputs (in kg./h.p./hr.) are 20 for PVC, 25 for nylon, 35 for polystyrene and 40 for cellulose acetate.

Another exhibit is a hammer mill made in various standard sizes which is usually supplied with fan, cyclone separator, sack-filling equipment and the necessary air ducts. Capacities range from 3 kg./h.p./hr. for wood flour, 50 for bone meal and to 180 for lime. In special cases the mills are made to deliver directly into sacks or are provided with elevators or worm conveyors. The *Amerique* mixers consist of a trough with a central shaft, with four concentric opposed screw blades. The machines are used for mixing a wide range of dry or wet materials, including foodstuffs and chemical products. It is stated that the time required for obtaining a homogeneous mixture seldom exceeds from 1 to 2 min. Provision is also made for rapid discharge, either into sacks or storage bins, so that from 15 to 20 batches can be completed in an hour. Finally, there are automatic control systems for stopping and restarting motors actuating the grinding or conveying mechanism, etc. This arrangement prevents overloading and allows the maximum power to be developed without danger.



The 'Polybloc' heat exchanger, displayed by Société Le Carbone-Lorraine, is assembled from graphite blocks which are held together under compression by external tie bars. The heat-exchange surface of the axial passages of each block is 6.46 sq. ft., while that of the radial passage is 4.33 sq. ft. By arranging several blocks in parallel or in series, a number of combinations is possible.

Le **Grès Francais**, 4 rue de Copenhague, Paris VIII, are manufacturers of all types of ceramic tower packing rings used in the chemical and associated industries. They also supply porous porcelain for filtration and special heat- or shock-resisting bodies made of stoneware. (Stand No. 152, Lavoisier passage.)

Heito, 13 rue Augereau, Paris VII. Manufacturers of laboratory apparatus, *p*H meters with direct reading, and special electrical apparatus. (Stand No. 301, Henri Moissan passage.)

Herfilco Cominex, 44 rue la Boetie, Paris VIII, suppliers of filters for industrial purposes, are displaying self-cleaning filters and manual-pressure leaf filters. (Stand No. 252.)

Johnson, Matthey & Co. Ltd., 73-83 Hatton Garden, London, E.C.1. This company's display includes some items of silver and platinum equipment for chemical engineering, bursting discs and bursting disc assemblies, precious metal catalysts, and spinning jets for artificial fibre production. A range of Matthey cadmium pigments are also shown, together with typical pigmented plastic materials and finished articles. Further sections of the display are devoted to platinum laboratory apparatus, spectrographically standardised substances and high-purity elements, platinum-wound electric furnaces, products for measurement and control and low-temperature silver brazing alloys.—(Stand No. 1033, Group C.)

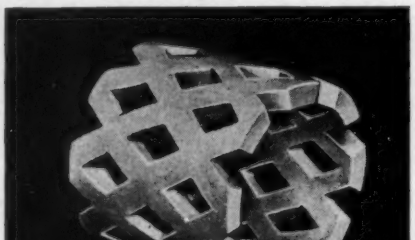
Julien & Cie, 104 rue Kleber, Marseilles. Suppliers of valves, pumps and apparatus for the chemical and petroleum industries. Exhibits include a special process of plastic packing claimed to provide durable sealing, repacking under pressure in any position of the stem; and special design with *Teflon* disc for tight shut-off to withstand severe and dangerous conditions. (Stand No. 246, J. B. Dumas passage.)

Kern & Cie S.A., Aarau, Switzerland. The micro-electrophoric apparatus L.K. 30 is used for the determination of changes in the refractive index in a cell by measuring the degree of interference. The optical system causes a beam of light to pass through the cell twice, thus doubling the effect. The diagrams which are obtained show the two compartments of the cell with striations caused by interference effects, which resemble the section of a landscape with contour lines, and enable changes in the index of refraction to be determined. The difference in height between two adjoining plateaus gives the relative concentration in the corresponding fraction of the liquid in direct values without the necessity for any integration.

Krebs & Cie Paris, 38 rue Parmentier, Neuilly-sur-Seine. The company design and install chemical and electro-chemical plant. Their display consists of photographic documentation. (Stands Nos. 343, 310 and 70A.)

Etablissements **Kustner Freres**, 103 Avenue Rouget de l'Isle, Vitry-sur-Seine, present their new laboratory mixers of 800 ml., 1 l. 600, 5 l. and 10 l. total capacity. The drive for the mixers is through a reduction gear mounted directly on the frame of the machine. The gearing is enclosed in a sealed housing. The body and blades are machined and polished. The relationship of the speed of the blades to the dimensions of the trough has been given particular attention. The trough can be easily emptied by tilting by means of a hand lever. Glands are provided which prevent the penetration of materials into the bearings of the machine. The trough is easily and thoroughly cleaned by taking down the machine.

Langley Alloys Ltd., Slough, Bucks, England. A wide range of this company's corrosion-resisting valves, certain of which



Ceramic tower packing rings and various stoneware items are being shown by Le Grès Francais. The perforated cylinder illustrated is made of acid-resisting stoneware and is available glazed or unglazed.

incorporate new design features, are exhibited, along with various fittings and castings. Y-valves, globe, gate, needle, check valves and Y-type strainers are included as well as impellers, pump bodies, valve components and marine equipment, all in various materials. (Stands Nos. 179-183.)

Société **Luceat**, 37 Boulevard Malesherebes, Paris VIII. This company are showing their storage tank equipment, safety devices and checking devices. A special exhibit is a pilot-operated safety valve of the direct-closure type. Features of this, according to the makers, are gas tightness proportional to pressure build-up, immediate full-flow capacity at set pressure and resistance to corrosive vapours. (Stand No. 406, Reaumur passage.)

Lumpp & Cie, 12 rue Jouffroy-d'Abbans, Lyon-Vaise, are exhibiting plant for the chemical industry including centrifugal separators and decanters, high-vacuum pumps, compressors, vertical and horizontal acid pumps, valves, fittings and pipework for acids, plug valves for high-vacuum high-speed vertical agitators, portable adjustable agitators, fume exhausters, and filter presses. (Stand No. 121A, Paul Kestner passage.)

Manufacture Francaise de Vide-Touries Antomatiques, Paris XVI, are exhibiting a range of automatic carboy and tank waggon syphons, valves and pumps for handling acids and other aggressive chemicals. Many of these appliances are fabricated entirely of rigid PVC or, in the case of valves, the plug is encased in polythene or *Teflon*.

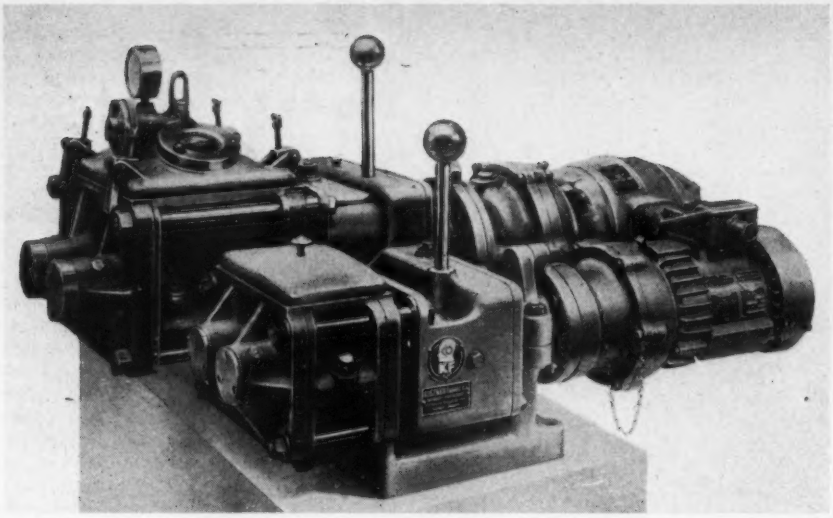
The smaller syphons for carboys are operated by means of a flexible rubber bulb or a hand-operated barrel suction pump. This equipment is supplied in PVC, hard lead, ebonite, aluminium, brass or stainless steel. Automatic tank waggon syphon dischargers are actuated by either a mobile hand pump mounted on a trolley or by a mechanism attached to the chassis of the waggon.

Various types of dust masks are also being shown. These consist of simple pads covering the nose and mouth or of more elaborate respirators with a filter canister or bag. The latter can be reconditioned by washing in a special solution containing a detergent and a disinfectant. (Stand No. 287, Marcelin Berthelot passage.)

Meci, 123 Boulevard de Grenelle, Paris XV. Automatic control. Electronic instruments, pyrometers, flow meters, pressure gauges, pneumatic and electrical controllers, gas analysers, *p*H meters, conductivity recorders and a polarograph will be exhibited. (Stands Nos. 240 and 277, Perrin, Dumas and Berthelot passages.)

Entreprise René & Jean **Moritz**, 3 Avenue de Pomereu, Chatou (S. & O.), are exhibiting plant and equipment for the chemical industry in three sections of the Salon. The range includes turbo-agitators for preparing simple mixtures, turbo-reactors for operations involving emulsions and intensive mixing, turbo-colloid mills for preparing dispersions and for homogenisation, and super colloid mills which are used in conjunction with the above machines for obtaining the highest degree of fineness in colloidal dispersions and emulsions. A continuous homogeniser is also being shown which is used for the preparation of bituminous emulsions, continuous saponification, aeration of greases, etc. The company has developed a vanadium oxide catalyst on a kieselguhr base which gives an efficiency of 98% conversion of SO_2 to SO_3 and a yield of 5 kg. H_2SO_4 per kg. of catalyst per day. The service life of the catalyst is from eight to ten years under continuous operation. A new method for the manufacture of acid by the contact process has been patented which involves the use of the turbo-absorber.

Grinding equipment includes the well-known ball mills fitted with an air-separation system; the *Microniser*, a hammer mill



Laboratory mixers displayed by Kustner Frères have a reduction gear mounted directly on the frame of the machine. These two models have capacities of 1 litre 600 and 5 litres.

which reduces materials to the fineness of a micron and is supplied with or without air separation; and laboratory disc mills with ferro-manganese grinding elements. The company are also showing electrolytic plant for the manufacture of chlorine, caustic soda and sodium hypochlorite, hydrogen and oxygen. The latter consists of 30 bi-polar cells producing 5 cu.m./hr. of hydrogen.

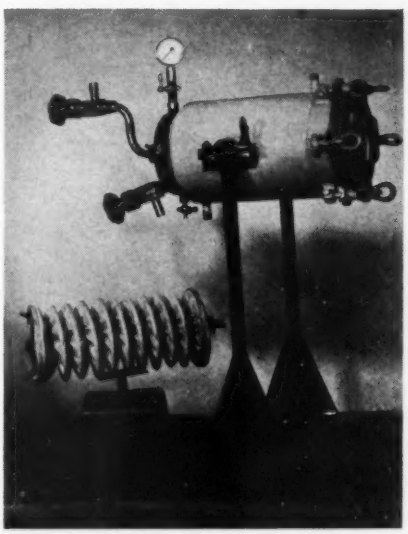
The company are also exhibiting electronic generators manufactured in France under licence from Redifon; a high-frequency heater used for preheating plastics before moulding; an induction heater with an effective output of 2.5 kw. suitable for continuous processes such as welding, brazing of heat treatment in the automobile industry; semi-automatic welding equipment made under licence from Rediweld for plastics such as polythene, pliofilm or coated paper. (Stand No. 80, Berthelot passage.)

Niro-France S.A.R.L., 82 rue Saint-Lazare, Paris IX. This company is exhibiting two spray driers—one for laboratory use and the other for use on a semi-industrial scale. (Stand No. 96, Matignon passage.)

Etablissements A. **Olier**, Postbox 70, Clermont-Ferrand, France. The display includes stainless-steel equipment for the chemical, pharmaceutical and allied industries. Examples of this company's other products are machines for treating rubber and plastics; a continuous diffusion system for sugar beet; complete installations for oil mills and for treating fats; plastics moulding machinery, etc. The *Universelle* continuous oil expeller is provided with a very large filtering surface and with a feeder screw turning at high speed. The silent twin drive of the expeller is obtained by using a bronze worm gear running in oil. (Stands Nos. 169-171, Lavoisier passage.)

O.P.L. (Optique et Precision de Levallois), 10 rue Auber, Paris IX. Manufacturers of optical and scientific instruments. The universal refractometers exhibited, with heated prisms, are stated to be suitable for controlling or determining the concentration of aqueous etheric solutions, as well as of certain acids and alkaloids. Another item displayed, the metallographical microscope, provides a method for structural analysis of metal samples and other substances. (Stand No. 5, Branly passage.)

Oronzio de Nora—Impianti Electrochimici, Via Bistolfi 35, Milan, Italy. This company engage in the design, engineering and construction of chemical plants. Their display includes flowsheets and photographs of processes and plants for the manufacture of chlorine and caustic, hydrogen peroxide, sulphuric acid and fatty alcohols. Diagrams relating to detergents and fertiliser factories are also shown. (Stand No. 120, Chevreul passage.)



A helical filter marketed by Etablissements A. Olier.

O.S.I. (Omnium Scientifique et Industriel de France), 141 rue de Javel, Paris XV. The company supply equipment for scientific and industrial laboratories. They are displaying a selection from their range of electric furnaces for temperatures up to 2,000°C.; constant-temperature drying ovens with a range from 50 to 400°C.; constant-temperature baths; water stills, electrically heated, for wall mounting; electrolytic analysis apparatus with rotating beaker; and a range of apparatus for petroleum testing.

Société des Aciéries de **Pompey**, 61, rue de Monceau, Paris VIII. Steel products. Exhibits include high-grade carbon and alloy steels resisting the corrosive action of acids, nitrates and brine; steels highly resistant to ageing; and cast alloy steels. (Stands Nos. 394-396, Reaumur passage.)

Prache & Bouillon, 37 Ave. Franklin Roosevelt, Paris, are exhibiting water stills for laboratories, mirror works, garages and boiler feed water; evaporators for concentration of chemical products and foodstuffs; crystallisers for salts, sulphates, phosphates, etc.; steam compressors; steam reduction valves; and heat exchangers. (Stand No. 290, Marcelin Berthelot passage.)

Société de **Produits Chimiques des Terres Rares**, 67 rue de Prony, Paris XVII. This company are showing their range of rare earth metals and derivatives. Products are used in: *Glass manufacture*—oxides of various metals, especially lanthanum oxide, are used in the production of special optical glasses; *Cerox* are products based on cerium oxide which are specially prepared for polishing glass. *Metallurgy*—mischmetal and various metals derived from the rare earths are used for improving the properties of stainless and other special steels and for the production of light magnesium alloys. *Manufacture of carbon electrodes*—the fluorides of cerric earths are accessories of this industry.

The manufacture of ferro-cerium in the form of lighter flints is one of the principal activities of the company. (Stand No. 1327, Vauquelin passage.)

Société **Prolabo**, 12 rue Pelée, ParisXI. Makers and suppliers of laboratory equipment and materials. Exhibits include pure chemicals, laboratory apparatus and scientific instruments. (Stand No. 1A, Edouard Branly passage.)

Proxima, S.A.R.L., 59 rue La Boëtie, Paris VIII, are exhibiting products from the following firms:

Alpine A.G., Augsburg—Grinding mills and air separators of which the following are of particular interest. *Contraplex* mill, consisting of two pinned discs revolving at high speed in opposite directions, without sieves. *Mikroplex* separator, for separating powders into two fractions, one below and the other above a predetermined degree of fineness, which can be as low as 2 microns.

Theodor Christ, Basle.—Water softeners and demineralisers, including a water demineraliser with a single layer of medium giving a degree of purity equal to double distilled water. The ion exchanger is a resin of the polystyrene type.

Henschel, Kassel.—Agitators and mixers. These agitators are based on a novel principle. The rotor is shaped like a milling machine head and throws the particles of liquid against a series of pins. The throughput of this machine is particularly high and it is suitable for use with liquids having a viscosity of up to 50,000 cp.

Gebr. Ruhstrat, Göttingen.—Electric ovens. The Nernst-Tammann type of electric furnace which can give temperatures of up to 3,000°C. is of special interest. (Stand No. 117A, Sainte Claire Deville passage.)

Quartz & Silice, 8 rue d'Anjou, Paris VIII, are exhibiting items of chemical plant made of pure fused silica. (Stand No. 48 m2, Pierre et Marie Curie passage.)

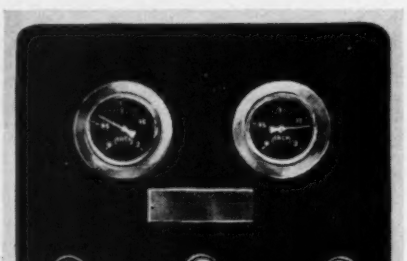
Les Appareils **Ramm**, 39 rue de Liege, Paris VIII. Equipment for the chemical/allied industries. This company is displaying for the first time a portable spray-drying apparatus which can be used in the laboratory or in small-scale industrial production. Other exhibits include back-pressure steam turbines, evaporators, etc. (Stand No. 390-392, Reaumur passage.)

Optischewerke C. **Reichert**, Hernalser Haupstrasse 219, Vienna XVII, Austria. This company's display represents a range of microscopes for use in biology, metallography and chemistry, as well as stereoscopic microscopes, microtomes, photomicrography apparatus, etc. The large metallographic microscope Me-A can be arranged with reflex camera, optical bench, arc lamp and low-voltage lamp, and is for all kinds of metallographic work in incident and polarised light. The heating and cooling stage RCH microscope is used for the exact determination of the physical and chemical properties of organic and chemical substances and for thermoanalysis. Another item of apparatus is the Kofler hot bench for the microscopic determination of the melting point and the purity of organic substances. (Stand No. 49A, Jean Perrin passage.)

Etablissements **St. Chamond-Granat**, 23 rue d'Aumale, Paris IX. Remote control and regulation servomechanisms. Exhibits include remote recorders for levels, temperatures and pressures, and signalling devices. (Stand No. 306, Henri Moissan passage.)

Les Fils de Emile **Salmson**, 44 Avenue de la Glacière, Argenteuil (S. & O.). This company are displaying their range of centrifugal pumps for laboratories, pilot plants and the chemical and allied industries made with cast iron, bronze, stainless steel, plastics, etc. Among these are the pump No. 72 with stuffing box for sealing fluid, a vertical centrifugal pump with no stuffing box and no submerged bearing, a laboratory pump in *Teflon* with mechanical seal, etc. (Stand No. 206, Gay-Lussac passage.)

Sepieg S.A.R.L., 26 rue de Naples, Paris, are exhibiting an apparatus used for the hot spraying of thermoplasts such as paraffin wax, micro-crystalline wax and its compounds, cocooning materials, pitch and bitumens. The principle of the apparatus is to heat the material to a temperature at which it becomes sufficiently fluid for spraying by means of a stream of compressed air. The molten material is stored



An external view of an Arca-Bröida electro-pneumatic controller with its two pressure gauges showing the air pressure acting, on one hand, on the controlled component (diaphragm valve, power cylinder, etc.) and on the follow-up device and, on the other hand, on the automatic reset device. The three knobs seen on the panel correspond respectively to the setting of the desired control point of operation, to the adjustment of the desired throttling range and to the starting or stopping of the controller. The adjustment for the rate of automatic reset is located behind the front panel of the controller.

under pressure in a container and a suitable temperature is maintained by means of an electric heater. The liquid is conveyed to the spray gun through heated flexible metallic tubing where it meets a stream of heated air conveyed by a similar tube. These tubes are covered with heat insulation and are heated by a low-voltage current, the temperature being controlled by a thermostat.

The apparatus, known as 'Atoplast 20,' is stated to be suitable for spray application of all liquid thermoplastic materials at temperatures up to 250°C. This process has many industrial applications, including anti-corrosion linings for the chemical industry.

S.E.S.I. (Société des Ecrémeuses et Séparateurs Industriels), 30 rue des Alouettes, Paris XIX. This company is displaying the products of Westfalia Separator A.G. (Germany), including clarifiers, a desludger, separators, a mixing machine and a centrifugal extractor (liquid/liquid) with two feeds and two discharge pipes. A laboratory centrifuge which can be used as a separator, concentrator or clarifier is also shown. (Stands Nos. 386 and 388, Reaumur passage.)

Société **Sinnova**, 42-44 rue de Chézy, Neuilly-sur-Seine. This company, which has just increased its production capacity by the inauguration at Toulouse of a new factory for the manufacture of fatty alcohols by catalytic hydrogenation under high pressure using the latest techniques, is displaying the complete range of its principal products. These include the *Sipols*, fatty alcohols obtained either by the sodium process developed by Sinnova for continuous production or by the catalytic method, as well as a variety of derived products: anionic, cationic and non-ionic. The series of anionic products, the *Sipons*, include products in liquid, pasty and powder form, with a large number of applications. Sinnova are showing their quaternary ammonium salts: *Bacfor* AD or *Germibac* Br concentrated—a strong bactericide, fungicide and germicide used in agriculture and in numerous industries; and *Bacfor* BC, whose chief use is in cosmetology for vitalising preparations. The series of non-ionic products, which find applications in cleansing, dispersing, emulsifying and wetting, comprises the *Emulphors* and *Mergitals*. The company are also showing another group of fatty alcohol derivatives, the self-emulsionable waxes of *Sipols* SX, SX5 and AO, which are used in a number of cosmetic and pharmaceutical preparations. Finally, there is a variety of alkyl-aryl sulphonates.

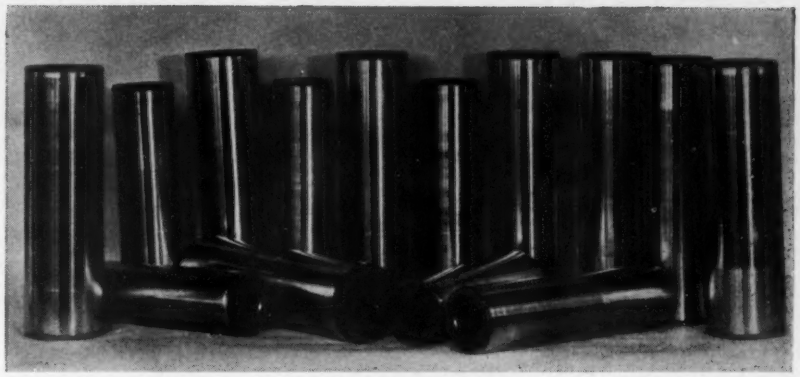
Stinox (Société Industrielle de Transformation des Aciers Inoxydables), 8 rue du Débarcadère, Paris XVII. Suppliers of clad plates, stainless steels and special alloys. Exhibits include clad plates (stainless, Monel, nickel, etc.), Haynes-Stellite alloys for hard-facing, special electrodes, titanium, stainless and heat-resisting steels, etc. (Stand No. 254, J. B. Dumas passage.)

Etablissements André **Walter**, 37 Boulevard Saint-Michel, Paris V. Manufacturers of medical and scientific instruments. Among this company's exhibits is an electric analyser for powders, dusts and pigments; an electrodensimeter for controlling the current density of electrolytic baths; an ageing apparatus for coloured pigments (fading test); an instrument for determination of breakdown voltage of protective coatings (insulation); and apparatus for measuring the thickness of protective coatings. A further exhibit is an apparatus for measuring dielectric stability. (Stand No. 22, Branly passage.)

Hard Surfacing with Chromium Boride Alloys

CHROMIUM boride alloys have been used for the past 20 years for the hard surfacing of components which are subject to severe abrasion, corrosion or oxidation. During this period the number of alloys has been increased to ten from the original one. The field of applications includes general engineering, chemical and food manufacture, oil refining, the manufacture of grinding and quarrying equipment, etc. The latest development is an alloy for brazing stainless steels and nimonic alloys, for operation at a high temperature.

The alloys are manufactured in two main groups: in the first, chromium boride is used on its own or alloyed with steel; in the second, the chromium boride is alloyed with nickel. By varying the percentage of chromium boride alloyed with the base metal, products of varying hardness and machineability can be obtained, ranging from 15 up to 72 Rockwell *C*.



Pump sleeves of stainless steel hard faced by 'Sprayweld' process and rough machined with carbide-tipped tools.

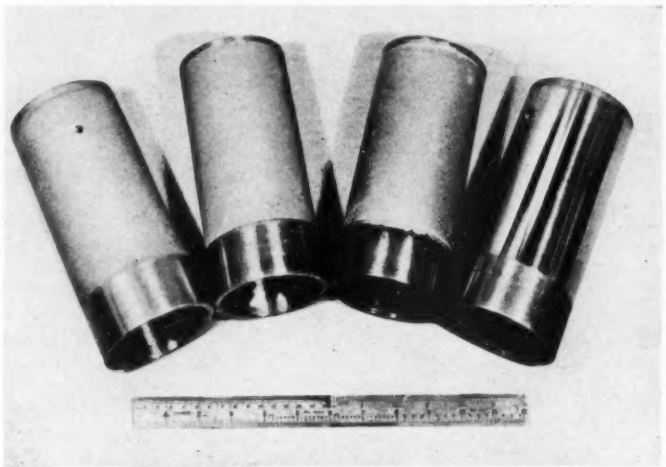
Ferrous-base alloys

For use on its own, chromium boride is supplied in the form of a paste which is spread over the component to be treated and allowed to dry. For thin applications of up to .020 in., the paste is sweated into the base metal, using an oxy-acetylene flame. For deposits of up to ⅛-in. thick, the chromium boride is fused, using a carbon electrode with a d.c. arc-welding machine. In both cases, the chromium boride alloys with the base metal to form a hard, wear-resisting surface. Chromium boride is also available as a metallic-arc electrode, having an iron core and a chromium boride coating, which is suitable for building up components worn undersize and where a resistance to impact is required. These two alloys are primarily intended for rough applications such as earth-handling equipment, digger teeth, bucket lips, swing hammers, etc.

Chromium boride with tungsten and iron is produced as a cast welding rod for building up cutting tools such as reamers, milling cutters, lathe tools, etc. This alloy has some resistance to corrosion and has been used for machining plastics and light alloys.

Nickel-base alloys

With these alloys, the chromium boride is alloyed with nickel in varying percentages, and is available as cast rods, either bare or coated, for oxy-acetylene or electric arc application, or in powder form for use with the modified metal-spraying process known as *Spraywelding*. The softest alloy, which has a hardness of 15 to 20 Rockwell *C*, can be readily machined or filed, whereas the hardest alloy, having a hardness of 56 to 62 Rockwell *C*, can only be ground or rough-machined with carbide-tipped tools. These nickel-base alloys are stated to be suitable for application to chemical plant on such parts as mixer shafts, pump rods, etc., where these components are working in sealing glands.



Pump sleeve showing the four stages of the 'Sprayweld' process. *Left to right:* (*a*) **Recessed for Colmonoy and grit blasted;** (*b*) **sprayed with Colmonoy to required thickness;** (*c*) **fused deposit;** (*d*) **finish ground sleeve.**

Application by spraying

The harder grades of nickel alloys have a plastic range of up to 100°C. and, as a result of this feature, some of them can be applied in powder form by metal spraying, the sprayed deposit subsequently being fused into place by the application of heat. Owing to the plastic range, the sprayed deposit does not lose its shape, and therefore smooth applications can be made to regular- or irregular-shaped machine parts, which require very little maching or grinding to bring the component to size. The fusing process is stated to weld together the sprayed particles and weld the deposited metal on to the base component, so that the hard surface cannot be stripped away and is free from porosity or hair cracking. The thickness of the deposit can be controlled while the spraying process is being carried out, as the work remains cold enough to measure accurately, and it is usual to leave only .010 in. to .015 in. of material for finish grinding and machining. The accuracy with which *Spraywelded* deposits can be made materially reduces the finishing time on a component. In some cases, it is possible to cut out grinding.

As an instance of the use of the nickel-base alloys for pump parts and valve seats, the suppliers of *Colmonoy* materials, A. S. Young & Co. Ltd., cite the case of a pump handling detergents, on which a pump rod has been in service for two years without showing any signs of wear. Previously, a stainless-steel rod had been replaced every month.

Materials of Construction for Chemical Plant

IN the preface the author states that this book* is written to introduce to students of chemical engineering the essential properties and limitations of materials from which chemical plant must be constructed. The aim of the book is to bridge the gaps which exist in the knowledge of those trained, on the one hand, in mechanical engineering and, on the other, in chemistry. He considers that chemical plant must be primarily designed for corrosion resistance, and only in a secondary degree for strength as distinct from normal engineering practice.

The book commences with a chapter on the mechanism of corrosion and this is followed by a chapter on testing of materials. The rest of the volume consists of sections dealing with specific materials used in chemical engineering plant such as cast iron, steel, ferrous alloys, lead, aluminium and magnesium, copper and copper alloys, nickel and nickel alloys, silicon iron, precious metals, protective coatings on metals, inorganic cements, organic cements and luting materials, bricks, tiles and stoneware, refractories and insulating compounds, vitreous silica and hard glass, wood, plastics and rubber. It is rather surprising to find metals like molybdenum, titanium and zirconium included in the chapter on precious metals, as the term ' rarer metals ' is in common usage.

The first chapter attempts, in the space of 23 pages, to deal with the whole scope of the mechanism and principles of corrosion and, according to his statement in the preface, the author has assumed that the reader possesses little knowledge of physical chemistry. The result is that this chapter is confused and presents very difficult reading. This section is far too condensed and it would have been better if more space had been allocated to this most important aspect of the book. Surely it is not unreasonable to assume that most students of chemical engineering when they reach the stage in their course of being concerned with materials of construction will have acquired a sound background of physical chemistry.

Thus, explaining the corrosion of iron with the evolution of hydrogen, the author writes: ' The potential of the cell will diminish as a result, and the complete formula for the potential of an iron electrode can be written as

$$Fe/Fe^{++} - 0.440 \text{ v.} + (0.030 \log_{10} C)\text{v.}$$

where the effective concentration of ferrous ions is C times the normal value. The constant 0.030 is for a divalent ion; for monovalent ions this is altered to 0.059 and for trivalent to 0.020.'

This method of presentation, apart from an obvious error, is hardly excusable in a book of this standard.

The section on testing of constructional material deals with both mechanical and corrosion testing and is concise and to the point, but one wonders whether this section is really essential in a book of this description.

The sections on metallic materials of construction are particularly good, the author dealing in fair detail with the physical metallurgy, fabrication and corrosion-resisting properties. In these chapters the author fulfils his object, as they contain a great deal of information which is of value to students of chemical engineering and to the chemist and engineer. Thus the chapter on cast iron deals with the iron-carbon system and equilibrium diagrams, the solid structure of cast iron, impurities in cast iron, mechanical properties, cast-iron compositions, cost, and resistance to corrosion in both natural and chemical environments. The other chapters follow a similar pattern.

The book is well illustrated by very clear graphs and diagrams and by numerous photographs of metallographic structures and chemical plant.

Apart from the weaknesses mentioned, this book forms a valuable contribution to the study of chemical engineering both as a work of reference and as a textbook.

L. L. SHREIR

Chemical Engineering Materials, by F. Rumford. Constable, 1954. Pp. 380, including index. 32s. 6d. net.

Recent publications

Plastics for industry. Two new illustrated pamphlets describe the properties and uses of Bakelite laminated materials. One deals with the use of these materials for jigs and tools, while another covers applications in the aircraft industry. A third publication contains data concerning *Vybak* rigid PVC sheet, with instructions for machining and welding (this material was described in CHEMICAL & PROCESS ENGINEERING, November 1953). Finally, a 20-p. illustrated booklet by Warerite Ltd., a subsidiary of Bakelite Ltd., provides architects and fabricators with information on the applications of *Warerite* veneered boards and panels for interiors.

Grinding, blending, sifting and mixing. Machines for each of these operations are described in a new leaflet from Pascall Engineering Co. Ltd. For grinding they offer several end runners, a laboratory edge runner, four sizes of laboratory ball mills and a pin disc mill. A sifter capable of dealing with chemicals, colours, cosmetics, foodstuffs and plastics is described as a vertical turbine rotating inside a stationary cylinder of mesh surrounded by an outer cover. A test sieve vibrator, the *Inclyno*, is also made for test screen analysis. It is claimed that accurate screen analysis is possible with this instrument which entirely eliminates the human element. Other apparatus described are a powder mixer of which there are six standard models, and a triple-roll mill in three sizes; a small research mill for testing and sampling; a larger model for small-scale production and laboratory purposes; and a general-purpose production mill. Tables giving outputs, dimensions, power requirements, etc., are given in most cases.

Cable insulation with polythene and PVC. Polythene was first applied to cables about 1938. Since then it has been used as an insulation for submarine telegraph and telephone cables, underwater mining cables and almost every sort of submersible cable. PVC dates from the war years as an insulating material for cables, when it was used to replace rubber. Today it has a place in its own right in any consideration of cable insulation. Applications for PVC include the wiring of domestic and industrial premises and it is claimed to be of particular advantage where damp and corrosive conditions prevail or where the liability exists of oil or petrol contamination. Both PVC and polythene can be used in tropical countries, as they are not attacked by the termite. Full details are given in publication PCI/1 of the Telegraph Construction & Maintenance Co.

HCl absorption. Hydrogen chloride is encountered industrially over a wide range of concentration, often in association with mineral acids, solvent vapours, chlorine and other non-condensibles. The design of equipment for the absorption of hydrogen chloride is influenced to some extent by the specific conditions under which it will be required to operate, but basically the problem is that of providing the area of interfacial contact surface necessary to effect the required absorption, and of arranging for the efficient removal of the heat of solution generated. Hydrogen chloride is extremely soluble in water, but its absorption is complicated by the high heat of solution which it exhibits and the relatively high partial pressure of hydrogen chloride over its warm solution at commercially important concentrations. The major problem, therefore, is the efficient removal of heat. How this can be accomplished is explained in an illustrated pamphlet recently issued by Quickfit & Quartz Ltd., setting out some of the factors involved and describing briefly the type of industrial chemical glassware now available for this process.

(*More ' Recent publications ' on page 406*)

EVAPORATION

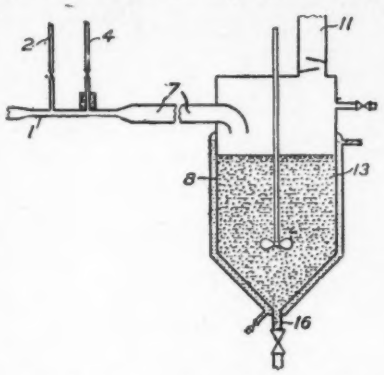
A slight error occurred in reference No. 6 given in the article by J. M. Coulson and M. J. McNelly in our October issue. The correct reference is: Lindsey, *Chemical Engineering*, 1953, **60**, 227.

Chemical Engineering Invention

RECENT BRITISH PATENT CLAIMS

Granular hydrolysed copolymers

This process is for obtaining, in a granular macromolecular form, hydrolysed copolymers of ethylene and a vinyl ester of an organic monocarboxylic acid, wherein the ratio of ethylene to the remainder of the molecule is from 1 : 1 to 4 : 1, and at least 50 per cent of the ester groups are hydrolysed. A stream of a solution of the hydrolysed copolymer in a volatile solvent



is brought into contact with a stream of steam, and the combined streams are maintained in a turbulent state until the solvent content of the copolymer particles thus produced has been reduced below the level at which agglomeration occurs. When the solution of hydrolysed copolymer contains the alkaline catalyst used in the hydrolysis step, this is preferably removed by neutralisation with acids such as acetic or stearic. Suitable vinyl esters are vinyl formate, acetate, propionate, butyrate, stearate, and benzoate. The volatile solvent may be a lower alcohol, or a mixture thereof with benzene, toluene, xylene, pyridine, dioxane or trichloroethylene, or water in admixture with methanol, ethanol, acetic acid, acetone, or dioxane.

In the apparatus shown, high-velocity steam enters pipe 1 and a dilute solution of colloidal material may be introduced into the steam from inlet 2 before coming into contact with the copolymer solution from inlet 4. The mixture is then carried along tail pipe 7 and discharged into a steam-heated catch pot 8 which contains a hot agitated liquid 13, such as water, which is a non-solvent for the copolymer, and which preferably contains a small quantity of a colloidal substance such as starch, methyl starch, glue, gelatine, casein, albumin, and sodium or zinc stearate. These form a thin film round the copolymer particles. Vaporised solvent issuing from line 11 may be recovered and re-used.

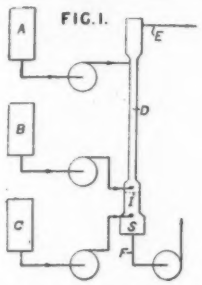
The slurry of copolymer particles is withdrawn through pipe 16, filtered, washed, and dried, providing a white granular powder of particle size from 6 to 150 mesh, which may be used in the manufacture of films, filaments, coatings, injection mouldings and extrusion products. Specification 607,911 is referred to.—659,836, *E. I. Du Pont de Nemours & Co.*

Petroleum cracking

A petroleum feedstock boiling within or above the wax distillate range is treated with a solvent for aromatic hydrocarbons to give an aromatic extract and a raffinate. The raffinate is dewaxed, and the wax and the dewaxed raffinate are separately subjected to catalytic cracking to give products which by fractionation yield gasoline of high octane rating.

Alternatively the raffinate may be subjected to cracking without prior dewaxing. Phenol is pumped from vessel *A* into the top of column *D*, down which it flows countercurrent to a rising stream of wax distillate containing 1.5% of sulphur, which is pumped from vessel *B* into the base of the column. The amount of phenol used is 80% by volume of the wax distillate. Water (5% by volume on the phenol) is injected from vessel *C* into the phase settler *S* to assist separation. The raffinate and extract phases are withdrawn from the top and bottom of the column through lines *E* and *F* respectively at such a rate that the interface *I* remains stationary. Each phase is passed to a stripping system for removal of the phenol. The raffinate is mixed with 400% by volume of a solvent consisting of acetone, benzene and toluene

FIG. 1.

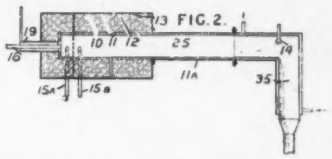


in the proportions by volume of 7: 10: 8, cooled to −20°F., and the separated wax filtered off at this temperature. The dewaxed raffinate and wax are separately cracked over a synthetic silica-alumina catalyst at 950°F. and a space velocity of 0.9 with a 2-hr. process period. In the example the dewaxed raffinate gave a 57% yield of gasoline with octane number 79, and the wax gave a 58% yield of gasoline with octane number 82. The sulphur contents of the two gasolines were 0.4 and 0.1%, respectively.—649,926, *Anglo-Iranian Oil Co. Ltd., J. N. Haresnape and E. C. Housam.*

Carbon black manufacture

Carbon black suitable for rubber compounding is produced by introducing vaporised oil having a low A.P.I. gravity, a low boiling range and a low end point into a cylindrical reaction chamber to maintain therein a longitudinal stream of reactant hydrocarbon. Free oxygen-containing gas is introduced tangentially to the inner wall of the reaction chamber to provide temperatures therein sufficient to decompose a portion of the reactant hydrocarbon to carbon black. The resulting mixture is passed through a semi-insulated after-reactor chamber of equal length and diameter to the reaction chamber to complete the carbon black formation with a limited heat loss therein. After shock cooling to 1,500°F., carbon black is separated.

FIG. 2.

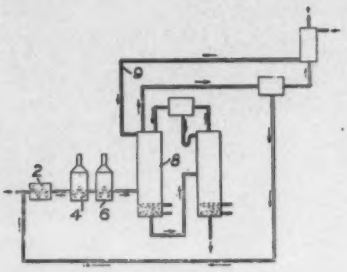


Recycle gas oil, of 16 to 25° A.P.I. gravity and of which at least 90% is vaporised at 700°F., preheated to 700°F., is introduced at 16 into reactor 10, having sillimanite lining 11 enclosed in insulation 12 with steel shell 13, at a rate defined by the formula $V = 50D^3$ where V = gal./hr. of gas oil and D = diameter of reactor in feet. Air is introduced through annular tube 19. Preheated air is injected through one or more tangential pipes 15*A*, 15*B*, at a rate of 400 cu.ft./gal. of oil, to form a helically-moving layer to prevent carbon deposition on the reactor walls and to maintain the reactor at 2,100 to 2,400°F. by reaction with the oil. The resulting gases pass to after-reaction 25, having sillimanite lining 11*A* only, and thence to the cooling assembly consisting of water-jacketed cooler 35 with water spray 14, air-cooling pipe and spray quencher (not shown) the carbon black is separated in an electrical precipitator or bag filter. Burner 15*B* may be of greater diameter than 15*A* and the length to diameter ratio for the reactor 10 may be 4.8. Specifications 607,296 and 621,031 are referred to.—649,091, *Phillips Petroleum Co.*

Reducing coke formation in Cr-Ni-steel cracking apparatus

This process is designed to reduce the formation of coke during the distillation or cracking of organic compounds in apparatus wherein the surfaces which come into contact with the material being treated are composed of high-chromium and high-

nickel steel. The surfaces are preliminarily treated with a gas containing a substantial proportion of carbon monoxide at a temperature within the range 1,200 to 1,800°F., and a pressure between 0 and 100 p.s.i.g. The steels to which the invention particularly relates, contain 23 to 27% chromium, 12 to 20% nickel, and less than 0.2% carbon.



The apparatus shown is suitable for cracking acetone to make ketene. The acetone is vaporised in coil 2, and is then preheated to about 1,200°F. in coil 4, which is of large diameter and is composed of the alloy referred to above. Alternatively the preheater may consist of rows of straight tubes connected in series or in parallel. The preheated acetone is cracked in coil 6 which is of less diameter than the preheater and is made of the same alloy as coil 4. The contact time is between 0.25 and 0.75 sec., the mass velocity being about 10—40 p.s.i./sec., and the outlet temperature being between 1,300° and 1,400°F.

The products are discharged into tower 8 where the ketene is reacted with acetic acid which is introduced through conduit 9. Prior to the cracking process, the apparatus is treated with carbon monoxide or a mixture of carbon monoxide and hydrogen at a temperature of 1,200°F. and a pressure of 5 p.s.i.g. for a period of 1 to 24 hr. The production of ketene from acetic acid and acetic anhydride is also referred to.—656,910, *Standard Oil Development Co.*

Roasting copper sulphide materials

Sulphidic copper-containing ores and concentrates are roasted by a fluidised-solids technique at 550 to 750°C. so that the copper is obtained in water-soluble sulphate) and acid-soluble (oxides) form, and iron present is insoluble ferric oxide. The fluidising oxygen-containing gas, which may be air enriched by oxygen or diluted with nitrogen as may be necessary, is employed, on the oxygen basis, not to exceed 400% over the stoichiometric amount, the excess being preferably of the order of 50%.

Multiple fluidised beds may be employed, some or all of the fluidising gas supplied to the lowest passing successively from bed to bed to the highest; alternatively, each bed may be independently fluidised by gas which is separately removed. A high temperature roast with a small excess of oxygen may be followed by a lower temperature roast with a larger excess.

The temperature of the bed may be controlled by spraying thereon a liquid, especially the residual solution remaining after the electrolytic precipitation of copper from the solution obtained by extracting the roasted material. Cooling coils may alternatively be used. Two forms of reactor and a flow diagram are shown.—668,119, *Dorr, Co.*

Catalyst chamber

A catalyst chamber has a grid formed of beams 16 (Fig. 2) extending across the chamber and supported near their ends on means attached to the chamber wall the beams being spaced to give spaces which are small compared with the beam width.

FIG. 2.

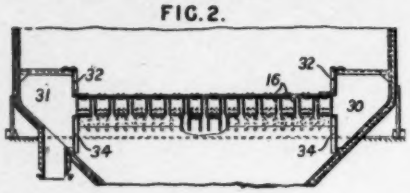
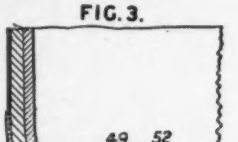


FIG. 3.

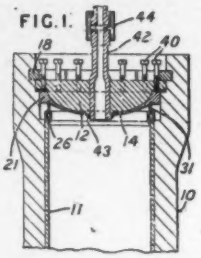


The beams are hollow and terminate in a sloping edge 15 (Fig. 3) adjacent the chamber wall and are closed by plates 17. Angle brackets 20 support the beams which are attached thereto by bolts 24 which have a higher expansion coefficient than the beams. In Fig. 3, baffle plates 32, 34 on the beams define overflow spaces 30, 31 which have outlets therefrom. Strips bridge adjacent beams and so provide a series of slots. A sealing plate extends around the inside wall of the chamber between the baffles 32. Openings 49 in the beam provide access to the bolts 24 so that individual beams may be replaced whilst openings 51 and associated filter 52 permit the escape of gas from the beam.—657,416, *Foster Wheeler Ltd.*

Pressure-reaction vessels

A reaction vessel for hydrogenation of coal or petroleum, or for catalytic synthesis of ammonia, has a body 10 of metal or of refractory material with a tightly fitting, replaceable body-liner 11, *e.g.* of an alloy of greater coefficient of thermal expansion than that of the body. At one or both ends, a head 12 held in place by a spring-ring 18 and faced by an end-liner 14. Set-screws 40 press an end-liner ring 21 against an annular, curved-section, spring sealing-ring 31. Square edges of the sealing-ring press against the sides of V-grooves in the ring 21 and a body-liner ring 26. Increased pressure or temperature thus tightens the sealing-ring 31. An outlet 42, with a sealing-ring 44, extends

FIG. 1.



through the head 12, and is welded at 43 to the end-liner 14. In modifications, the sealing ring 31 is integral with the end-liner ring 21; or the ring 31 is dispensed with, and the end-liner 14 welded to the body-liner ring 26 the two fitting into and being compressed in a V-groove in the head 12. In a further alternative, there is interposed between the end-liner 14 and the body-liner ring 26, a cylindrical ring welded to both and fitting, with the ring 26 into the V-groove in the head.—659,287, *Foster Wheeler Ltd.*

Homogenising valves

In a homogenising device, liquid is forced under pressure between two co-operating blocks separated by a narrow aperture. Two co-operating pairs of frusto-conical surfaces of different inclination provide two successive stages of homogenisation and one expansion chamber is formed by a recess cut at the junction of the surfaces. For any

FIG. 4.

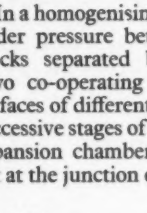
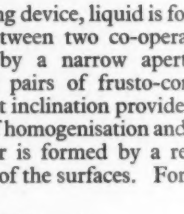


FIG. 1.

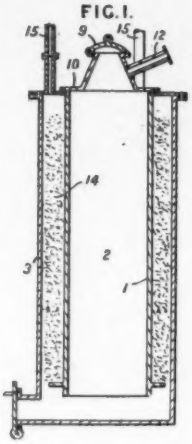


lateral displacement of the blocks from each other, the pair of surfaces of smaller inclination then have a greater separation and to this pair it is preferred to feed the liquid first. The pairs of surfaces 20, 26, 21, 25 on blocks 15, 16, are separated by an expansion recess 27. Liquid passes up the central passage 28 and leaves the second pair of surfaces *via* channels 30 formed in the upper block. An adjustable spring 11 is provided to force the blocks together.—656,915, *F. C. Potts* (*B. Trudel & Co. Ltd.*).

Carbon disulphide production

A retort for carbon disulphide production by the action of vaporised sulphur on carbonaceous materials comprises a preheating chamber filled with inert packing material, completely surrounding a reaction chamber and communicating therewith at one end. A gas-tight top cover for the reaction chamber may be opened to admit carbonaceous material.

FIG. I.



As shown in Fig. 1, the retort is formed of two concentric cylinders 1 and 3, the packed space 14 between constituting the preheating chamber. The top cover 10 can be opened at 9 and a pipe 12 is provided to remove reaction products. For carbon disulphide production the retort is placed in a furnace at 800°C. and liquid sulphur supplied by pipes 15 to the preheating chamber where it is vaporised and passed to the central reaction chamber 2 to react with the carbonaceous material therein. Specifications 291,382, [*Class* 1(ii)], 406,726 and 479,591 are referred to. —672,014, *Courtaulds Ltd. and L. Clunn.*

Purifying cellulose

Cellulose of a high degree of purity suitable for use in the production of cellulose derivatives is obtained by treating cellulosic materials with an aqueous caustic alkali solution of concentration 15 to 22% (calculated on a weight/volume basis in grammes of alkali per 100 c.c. of solution) at a temperature between 40 and 60°C.

The process may be applied to the further purification of wood pulp or straw pulp which has already undergone a preliminary purification and which has an alphacellulose content above 85% and a pentosan content below 3.5%. The further treatment may result in a cellulose having an alphacellulose content of 92 to 95% and a pentosan content below 1%. No subsequent bleaching is required. Preferably, 7 to 12 parts of alkali solution for each part of cellulose material (air-dry weight) is employed. The alkali solution may be preheated to the required temperature and the treatment of the cellulose may last for 45 to 90 min. After the treatment, the bulk of the solution may be removed by filtration, and the material may be washed to free it from residual alkali and the impurities contained in the solution. Hot water may be used for the washing. The last traces of alkali may be removed by washing with very dilute acid.

If alkali-cellulose is required, the cellulose may just be washed so that substantially all the impurities are removed without necessarily removing all the alkali, or the cellulose may be washed with an alkaline solution.

The alkali purification treatment may be applied alone or in association with other purification treatments. An impure cellulose pulp may be subjected to a chlorine or hypochlorite treatment prior to the alkali treatment or a relatively pure pulp may be given a boil with a very dilute alkali solution, *e.g.* of 2 to 3% concentration prior to or after the strong alkali treatment. The purified cellulose may be used for making viscose, cuprammonium cellulose solutions, cellulose ethers or cellulose esters and these may be employed in the production of artificial filaments, films, plastic compositions and moulding powders. Specifications 427,626, 470,764 and 509,938 are referred to.—640,490, *S. C. Bate.*

★ PERSONAL PARAGRAPHS ★

★ More than half a century's active association with steam generation was recently severed by the retirement of **Mr. B. Samuels** after 52 years with Babcock & Wilcox Ltd. After some years spent in the erecting department, he was transferred to the testing (now the service) department. He was appointed in charge of this work immediately after the 1914-18 war and the next 25 years was spent in building up the service department. He has been associated for some quarter of a century with the British Standards Institution; he has served on the General Council and is a member of the Engineering Divisional Council, the Council for Codes of Practice and the Solid Fuel Industry Committee.

★ **Mr. J. H. Plant** has recently been elected to the board of directors of Audley Engineering Co. to fill the vacancy caused

by the retirement of Mr. W. E. Parker a year ago.

Mr. Plant's first two years in industry were spent with British Rolling Mills Ltd., of Tipton, and then in 1939 he joined the staff of W. G. Allen & Sons (Tipton) Ltd. He was appointed secretary in 1940, a director in 1941 and joint managing director in 1949. This last position he still holds.

★ **Mr. W. R. Beldam,** director of Beldam Asbestos Co. Ltd. and other companies, died recently. After serving his time with W. H. Allen Sons & Co. Ltd., of Bedford, he joined his brother, Ernest, in the family business on his father's death in 1903. His special interest lay in technical and production problems and in 1923 he became founder director of Auto-Klean Strainers Ltd. He made a detailed study of straining and filtration problems and was responsible for a number of inventions in this field.

★ **Mr. George H. Marsden** has been appointed technical representative for the steel foundry department of Edgar Allen & Co. Ltd. He began work with the company 37 years ago and gained valuable experience in the foundry moulding shop, drawing offices and auxiliary shops, until in 1945 he was appointed chief inspector of steel castings.

★ Rhodes, Brydon & Youatt Ltd., centrifugal pump manufacturers, of Stockport, Cheshire, announce that **Mr. W. Latta,** sales manager, has been appointed a director of the company.

★ **Mr. J. Dean,** secretary of A.P.V.-Paramount Ltd., the foundry subsidiary of the A.P.V. Co. Ltd. at Crawley, Sussex, has been appointed a director of the company.

★ **Sir Wallace Akers,** C.B.E., died recently, aged 66. He entered the chemical industry in 1911. In 1941 he was appointed to the board of I.C.I., but almost simultaneously was seconded to the Department of Scientific and Industrial Research and took charge of atomic energy research. After the war he became research director of I.C.I., retiring from this position in 1953. In 1952 he became a member of the advisory council of the D.S.I.R.

Plant and Equipment

PVC filter medium

A filter medium which is claimed to combine fine particle retention with fast flow rate for both liquids and gases consists of pure unplasticised PVC (*Porvic*), 85% of which is composed of voids, leaving only 15% restricting material. The peculiar pore structure of *Porvic*, which results in only the small interconnecting channels being open to its surface, makes it in effect an edge filter.

As well as being used to separate solids from liquids the filter medium can be used to remove water from petrol, oils, etc., below a certain pressure. By employing certain wetting techniques the medium can also be made to separate out a wide variety of immiscible liquids. It can be supplied wetted with water for the ordinary filtration of aqueous liquids, including the removal of oils. Once wetted the material will resist the passage of air and other gases. This is particularly valuable in cases where aeration from a faulty pump or mounts must be guarded against.

The following advantages are claimed for the filter: no loose particles to contaminate the filtrate; no fibrous contamination; the medium does not weaken or become soggy when wet and is resistant to chemical attack; removal of cake by back-washing or after opening the filter is easy and complete.

Porvic is made in sheets up to 36 in. by 12 in. and in standard thicknesses of 0.003 in. and 0.050 in. Other thicknesses can be supplied if required. The sheets can be used in any filter press.

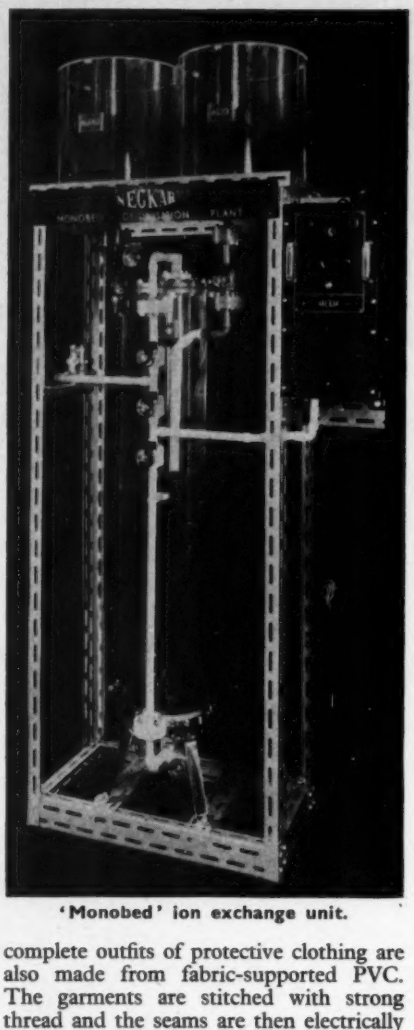
The new filter medium has been developed by British Filters Ltd. in association with Pritchett & Gold and E.P.S. Co. Ltd.

Protective clothing

A range of protective gloves and clothing, produced from a material consisting of a special PVC formulation, proofed on to a strongly woven cotton fabric, is being distributed by Northide Ltd. This firm also manufacture safety gloves in chrome leather, hide, cotton, asbestos, etc. High resistance to abrasion, chemicals and water are claimed for the range of garments manufactured of *North* PVC-coated fabric materials.

Fabric-supported PVC gloves are made in three types: fingered, one-finger mitt and full mitt, with two finishes—rough for hard wear and for gripping, and smooth for use with injurious chemicals. They are produced in a characteristic red colour, which the makers claim has the effect of concentrating the operator's attention on the job in hand, and assists him to judge distances more accurately when handling equipment.

Garments which can be made up into complete outfits of protective clothing are also made from fabric-supported PVC. The garments are stitched with strong thread and the seams are then electrically welded. The main seams have the stitching screened by a double thickness of coated fabric. This clothing is claimed to be resistant to acids, alkalis, greases, oils, spirits and waxes, and also non-ageing, waterproof and weatherproof.



'Monobed' ion exchange unit.

Heating element for furnaces

A new electric heating element for high-temperature furnaces is being produced by the Morgan Crucible Co. Ltd. The new element, which is marketed under the name of *Crusilite*, is a one-piece silicon carbide tube, produced by a completely new method, in which the central hot zone is in the form of a spiral of the requisite length. It is claimed to be entirely suitable for working over a wide range of element temperature from 800 to 1,575°C. (1,472 to 2,867°F.).

The makers point out that a disadvantage of other types of silicon carbide elements has been their rapid increase of resistance in use. Known as ageing, this characteristic has necessitated elaborate electrical arrangements to provide the voltage reserve needed to maintain the required power input. Even so, frequent replacement of the elements has been necessary every time their resistance has risen beyond the capacity of the power supply to provide adequate radiated wattage. The new element, it is claimed, ages more slowly and can be operated for very much longer without replacement.

Being in one piece, the *Crusilite* element has no cemented joints which might be a source of failure. Another feature is the terminal arrangement, at present available for the 10- and 14-mm. diameter elements only, which consists of special metal terminal caps shrunk on to the metallised ends of the elements. For furnaces where space is restricted and it is not possible to use these terminal caps, the elements can be supplied with metallised ends only.

Industrial ion exchange

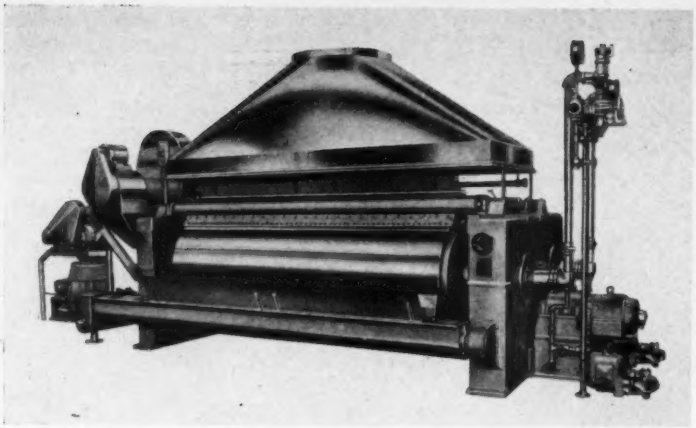
Ion exchange still finds the widest employment in the treatment of water. The oldest and best-known application is the exchange of sodium for calcium and magnesium in the softening of water, but the introduction of resinous ion exchangers opened up a much wider field.

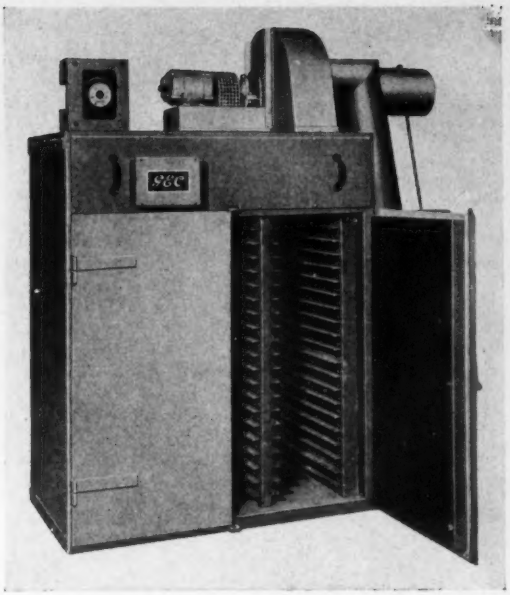
Nowadays ion exchange is an established process for producing pure water; it is stated that in the Neckar Monobed or mixed-bed system it is possible to produce water purer than distilled water. Normally two resins are employed, one for removing the cations (calcium, magnesium and sodium) and the other for removing the anions (carbonate, sulphate, nitrate and chloride).

In the original conception of the process of deionisation, as it is called, the treatment was carried out in two stages, the water first passing through a unit containing a bed of cation exchange resin and then through a unit containing a bed of anion exchange resin. In the more recently perfected mixed-bed or Monobed system, however, the resins are mixed and the water is treated in one unit only.

The accompanying photograph illustrates a typical Neckar Monobed unit, designed primarily to meet the needs of laboratories where very high-quality water is required. It is capable of treating up to 30 gal./hr. and will produce approximately 200 gal. between regenerations when dealing with London tap water. A larger unit by the same firm is capable of dealing with 200 gal./hr. and approximately 1,200 gal. between regenerations when treating London water.

When the resins are exhausted they have to be separated for regeneration, since the cation exchanger has to be regenerated with either sulphuric or hydrochloric acid, whilst the anion exchanger has to be regenerated with caustic soda. Separation is a simple matter; the water flow is





Above: **A 'Buflovak' double drum drier equipped with stainless steel conveyors, elevator, flaker and pulveriser. Blaw Knox Ltd., of London, recently concluded an agreement with the Blaw-Knox Co. of U.S.A. for the manufacture in Britain of 'Buflovak' equipment for evaporating, drying, solvent recovery and other processes.** *Right:* **Oven with 60 charge-carrying trays for drying powders, as described on this page.**

reversed so that it enters at the bottom of the unit and leaves at the top. The cation exchange resin has a slightly greater density than the anion exchanger, so that the two resins readily separate and can then be treated independently with their respective regenerants. After rinsing out the excess acid and alkali the resins are re-mixed by introducing compressed air at the bottom of the unit.

The purity of the water obtained by this process is superior to that obtained by the ordinary still. This is perhaps better appreciated when it is realised that, whereas distillation involves the removal of water from its impurities, deionisation effects the removal of the impurities from the water. From the mixed-bed process, water having a conductivity of 0.2 dionic units is obtainable, whereas the normal distilled water usually has a reading of about 5 dionic units.

The cost of producing pure water by this process, assuming London water, is approximately 20 gal. for 1d.

Hydrostatic dust collector

A hydrostatic dust collector which has been aded to the range of *Multiswirl* models is stated to be suitable for the many dusts created in the various processes connected with the manufacture of chemicals, plastics, paints, etc. Operations such as packing, grading, sieving and pulverising give rise to dusty conditions which in some cases, for safety reasons, require wet collection, whilst other dusts are more conveniently handled in sludge form.

Previously available in the MSE series and applied in the main as an individual unit for fettling booths, double-end polishers and grinders, the new series ME is available to handle large volumes of air and heavy dust concentrations. This new series, employing the Dallow Lambert patent hydrostatic cross-tube element, scrubs dust-laden air in either water or oil.

The unit operates without either pumps or sprays and, it is claimed, is suitable for use with all types of explosive dusts, foundry work, sanding operations, etc., special safety features being afforded for the handling of explosive materials.

Multiswirl collectors are manufactured in a range of sizes to suit all applications from 200 to 100,000 cu.ft./min., the larger sizes being fitted with multiple cross-tube elements and automatic sludge disposal. In the case of soluble dusts where no sludge is formed it is usual to arrange for drainage, continuous or intermittent, either to waste or to a reclamation process, according to the value of the dust.

These units are marketed by Dallow Lambert & Co. Ltd.

Drying of powders and chemicals

An oven designed by the General Electric Co. Ltd. for drying powders and chemicals has provision for a great number of charge-carrying trays. A forced-air circulation system ensures that the air flow is parallel to the tray surfaces.

The oven chamber is heated by wire-wound elements mounted in a separate compartment arranged as a drawer for easy access. A centrifugal fan on the top of the oven supplies the air flow which passes over the heating elements and is diffused down the oven side before passing horizontally across the chamber. An outlet is provided for purging moisture-laden air from the oven.

The accompanying illustration shows an oven with internal dimensions of 4 ft. 6 in. × 4 ft. 6 in. × 3 ft. deep, arranged to accommodate 60 work trays in three columns, and to provide temperatures up to 200°C. The oven can be supplied in a range of sizes.

'Push-button' chemical analysis

'Push-button' automation of complex chemical analyses is possible with the aid of a new automatic multi-component infra-red analyser just completed by the Perkin-Elmer Corporation. It is claimed that the new instrument automatically analyses up to 10 components in a sample in 10 min. Results are presented instantly on an electric typewriter, or a counter, or punch-card device. Instrument time is shortened by nearly 50% over usual manual spectrometer analyses and chances for human error are greatly reduced. The instrument was developed in conjunction with Ethyl Corporation and will be installed in their laboratories at Baton Rouge, Louisiana.

The analysers will be used primarily in the petroleum and petrochemical industries. However, it is applicable wherever there is a need for conducting large numbers of routine analyses of more than one component in a mixture. Since the analytical data is presented in a form ready for automatic computing, the operator has little to do except push a button.

The new instrument consists of a standard single-beam infra-red spectrometer. It is attached to a control unit which operates through 10 predetermined analytical wavelengths. These selected wavelengths depend upon the components to be analysed.

The sample cell is automatically shifted into and out of the infra-red beam to give quantitative readings.

The time required to cycle through 10 points is 10 min. Photometric accuracy in the 15 to 35% transmission range is claimed to be ± .002 absorbency units, and in the 35 to 60% range ± .001 absorbency units. Quantitative analyses are said to have been made with an average error of less than 0.1% absolute and a relative error of less than 0.2% of the amount present.

World News

GREAT BRITAIN

Record glass pipeline order

A record order for British industrial glassware has been placed by the University of California. The order, valued at about $10,000, is for 18-in.-diameter glass pipeline to be used for research purposes.

An official of Q.V.F. Ltd., suppliers of glass pipeline and industrial glassware, said that this was in fact the first shipment of 18-in. glass pipeline to the U.S.A. The American glass industry does not produce pipeline more than 6 in. in diameter.

Scottish Group of I.Chem.E.

There are approximately 120 members of the Institution of Chemical Engineers resident in Scotland; seven of these called a meeting last June, at the Royal Technical College, Glasgow, for the purpose of discussing a proposal to form a Scottish Group of the Institution. This Group has now been formed, with Dr. W. M. Cumming as chairman, Dr. W. L. Wood as vice-chairman and Mr. G. R. Campbell, Dr. B. Raistrick, Dr. F. Rumford, Mr. C. K. Steingold and Dr. D. M. Wilson as members of the committee. The honorary secretary is Mr. T. Flavel.

At a recent meeting of the Group, Prof. D. M. Newitt spoke on 'The Measurement of High Pressure.'

Additions and extensions at Power-Gas works

The second stage of development at the South works of the Power-Gas Corporation Ltd. and Ashmore, Benson, Pease & Co., of Stockton-on-Tees, has been completed. The first stage of development was completed in 1951 when the Power-Gas Corporation celebrated its golden jubilee.

In the constructional shops two transverse bays 85-ft. wide and 250-ft. long have been added, each with a 10-ton and a 20-ton crane. The two longitudinal 65-ft. wide bays which were originally 342-ft. long have been extended 170 ft. Various items of manipulating equipment have been installed to deal with the many types of work undertaken in mild steel, stainless steel, nickel, nickel-clad steel, *Inconel*, *Monel*, etc.

The new machine shop is 112-ft. wide —130 ft. if the annexe is included—and 250 ft. long with provision for an extension to 700 ft.

Ion exchange and its laboratory applications

A course of evening lectures on this subject will be held at Battersea Polytechnic, London, from January 27 to March 10, 1954. The course is intended for those with a degree or equivalent professional qualification and the subjects to be covered, in five lectures, are: general introduction, theory, analytical applications, inorganic applications, and biochemical and organic applications of ion exchange.

Socony-Vacuum and Powell Duffryn announcements

Since 1950 the ordinary share capital of the Vacuum Oil Co. Ltd. has been held equally by Socony-Vacuum Oil Co. Inc., New York, and the Powell Duffryn Group. Socony-Vacuum and Powell Duffryn now announce that they have signed an agreement under which Socony-Vacuum will acquire the 6,276,179 ordinary shares of £1 each held by the Powell Duffryn Group, and the latter will receive £7,250,000 5% Vacuum loan stock, 1960-85, which will be guaranteed as to principal and interest by Socony-Vacuum.

During the course of a statement to stockholders of Powell Duffryn Ltd., in which he explains the reasons for this change, the chairman of Powell Duffryn Ltd., Sir Herbert Merrett, points out that, since the original Powell Duffryn Group investment in the Vacuum Co. was made in 1950, there have been various far-reaching changes in the situation as it was then envisaged. First, the construction of the Coryton refinery has not only taken much longer than was anticipated, but has cost very much more than the original estimate. This increased cost has been due partly to the constantly rising trend in wages and in the cost of materials during the period of construction, and partly to the necessary introduction of additional equipment such as the *Thermofor* catalytic cracking plant which produces the premium grade of petrol now so much in demand in this country. The combined effect of these factors has been to increase the original estimates on the capital cost of the refinery by more than 50%.

Vacuum Oil's expansion

The 1953 report and accounts of Vacuum Oil Co. Ltd., issued recently, cover the commencement of the last stage of the company's expansion programme which began four years ago. The extent of the expansion during 1953 alone is evidenced by the increase in fixed and current assets from £19 to £27 million. Of this, some £5,900,000 represents expenditure on capital projects. After allowing for £1,247,842 depreciation, the net value of refinery and other buildings, plant and equipment, as at December 31, 1953, was £18,180,870. This reflects the completion of the greater part of the Coryton refinery, the completion of the new Birkenhead grease plant, the building of a coastal tanker and of various distribution terminals and, finally, the acquisition of the motor-transport vehicles and other marketing facilities necessitated by the enlarged scope of the company's operation.

The chairman, in his annual statement, refers to the late delivery of necessary materials and equipment—far later than had been promised by the manufacturers —to the site at Coryton. As a consequence of this, and of a prolonged strike in the electrical contracting industry, the catalytic cracking unit could not be commissioned until March of this year. Since that time it has operated satisfactorily.

Unforeseeable difficulties were also encountered where the lubricating oil units were concerned. Thus, during the abnormally extended period of start-up, the refinery operations have been without the benefit of income from those units which were expected to be most remunerative.

In contrast to the problems at Coryton, all aspects of production at the company's lubricating oil compounding and blending plants at Birkenhead and Wandsworth, and at the new Birkenhead grease plant, are described as entirely satisfactory.

Powell Duffryn Carbon Products

Despite the handicap of licences and exchange difficulties in foreign countries, Powell Duffryn Carbon Products Ltd. is maintaining its business in the manufacture and sale of heat exchangers and chemical engineering plant, states the chairman of Powell Duffryn Ltd. in his annual review. Powell Duffryn have disposed of their interest in the American partnership formed to develop the manufacture and sale of heat exchangers in the U.S.

Changes of address

Eimco (Great Britain) Ltd., manufacturers of *Rockershovels* and filtration plant, announce that the address of their head office and works is now: Team Valley, Gateshead-on-Tyne 11 (telephone: Low Fell 7-7241). Formerly they were at Leeds. The address of their London office is unaltered.

The Cardiff office of Babcock & Wilcox, formerly at 102 St. Mary's Road, is now at 26 High Street, Cardiff (telephone: Cardiff 29366).

Silver jubilee of Henry Wiggin works

The 25th anniversary of the founding in Glasgow of the Zenith works of Henry Wiggin & Co. Ltd. was celebrated recently. Zenith will always be associated with the introduction into Great Britain of *Monel*, the ubiquitous nickel-copper alloy developed by the International Nickel Co. of Canada Ltd. It was Lord Weir who obtained the concession to sell this material in Great Britain, and its initial development at the Cathcart works of G. & J. Weir Ltd. soon led to the setting up of a separate company, Monel Weir Ltd. The Zenith works, as the new factory was called, officially opened in 1929. Soon afterwards, the merger between the International Nickel Co. and the Monel Nickel Co. took place and Zenith works became an important and thriving department of Henry Wiggin & Co., a subsidiary of Mond Nickel.

New office

Honeywell-Brown Ltd. have opened their sixth area office to be established in Great Britain, this time at 95 Exchange Buildings, Mount Stuart Square, Cardiff.

The company are manufacturers of industrial instrumentation and automatic controls for space heating, ventilating and air conditioning.

I.Chem.E. examinations

The Institution of Chemical Engineers has recently published new 'Regulations for the Admission of Student, Graduate and Corporate Members, and for the Examination of the Institution.' These regulations contain the syllabuses for the Institution's examination which is to be held for the first time in 1956. The preliminary or Part I of the new examination will, however, also be held in 1955 immediately before the last examination in Papers C, D, E and F of the present examination as described in the Institution's pamphlet, 'Hints to Candidates.' The closing date for entry to both the present and new examination is June 1 in each year.

Scientific instruments and apparatus

About 140 exhibitors are expected to take part in the 1955 Physical Society exhibition of scientific instruments and apparatus. The exhibition will be held in the New Hall of the Royal Horticultural Society, Westminster, from April 25 to 28, 1955, inclusive. Exhibits will include scientific instruments and apparatus newly developed or in the process of development and pieces of research apparatus which make use of physical principles in ways hitherto unexplored. Among exhibitors of this type of apparatus will be a number of university departments and Government establishments.

SOUTH AFRICA

Chemical engineering laboratory

A South African correspondent informs us that the University of the Witwatersrand has been provided with a chemical engineering laboratory as a result of the interest of W. S. Thomas & Taylor Ltd. and of Kestners (S.A.) (Pty.) Ltd. They are providing most of the essential equipment. The firm of Cawse & Malcolm (Pty.) Ltd. have given an oil-fired vertical dross tube boiler. It has long been urged that the university be provided with such a laboratory, but it only became possible when the Yale telescope building was vacated.

As this building has a ceiling height of 35 ft., it is high enough to accommodate any item added to the plant. The units are being selected to illustrate fundamental principles rather than to do specific jobs.

The spray drier in the industrial test laboratory is used for the economic production of specified products; in the university laboratory it will be used to illustrate the theory underlying the unit operations of heat transfer and mass transfer. The method used to obtain the products is more important to the students than the products themselves.

It is anticipated that a greatly improved chemical engineering course will result from the creation of the laboratory. In the past the university could only teach the theory of operation of such units; now theory can be correlated with practice. Thus students will appreciate the limitations of existing theory and gain some familiarity with the practical aspects of plant operation. The university will give sound fundamental training and correlation with practice, but the engineer will still have to obtain practical experience in his chosen field.

While far from being a complete chemical engineering laboratory, the new equipment thus provided will yield a substantial nucleus around which it is hoped eventually to build a model laboratory.

The Leonard Hill Technical Group—December

Articles appearing in some of our associate journals this month include:

Corrosion Technology—Corrosion Research Laboratories, 2; Zinc-Rich Paints; Corrosion Control in Coil Spring Manufacture; Wooden Vats.

Manufacturing Chemist—Technology in the Fine Chemicals Industry, 5; Naturally Occurring Chlorine-containing Organic Substances; Alkylolamides; Progress Reports on Disinfectants and Disinfection, Analytical Chemistry, and Hormones.

Food Manufacture—Pineapple Canning in Kenya; Starch-filled Confections; Frozen Concentrated Fruit Juices, 2; Food Fortification.

Fibres—Recent Developments in Copolymers; Man-made Fibres in the Rubber Industry, 2; Ramie Fibre: Its Cultivation and Development; Wet Processing of Textiles; Electron Microscope; Fibre Data Sheet: Recognition and Differentiation of the Various Types of Chemical Fibres.

Petroleum—Corrosion in the Petroleum Industry, 2; Geophysical Methods of Oil Prospecting, 2; Theoretical Investigation of the Pressure, Temperature and Vaporisation Characteristics of a Tube Still; Queen Elizabeth II Oil Dock, Eastham.

Atomics—Elastic Scattering of Alpha-Po Particles on Hydrogen; Radiation Therapy with Radioactive Cobalt-60; American Standards for Radioisotopes.

Paint Manufacture—Accelerated Weathering of Paint; The Fire Hazards of Painted Surfaces; Trends with Titanium Dioxide; Modern Layout in Hull Paint Factory.

World Crops—Possibilities of Increasing World Food Supplies; Development of Spraying Machinery, 2; Forestry Policies in Africa; Field Experiments with Spray Nozzles in The Tropics.

Building Materials Digest—Enamelled Steel Plates as a Facing; New Roofing Material; Aluminium Hangar with a Clear Span of 200 Feet.

Muck Shifter—Hydro-Electric Power Scheme in Scotland, 2; Earth in Control of Water.

Dairyman—The Improvement in Margarine; Aluminium Milk Churn; Soft Cheese Manufacture; Bridge Farm Dairy.

SAUDI ARABIA

Import of pumps, restrictions

The British Embassy at Jedda has reported certain new restrictions on importers of pumps. The new regulations require that such importers should maintain 25% of the value of pumps imported in spare parts. The Customs have the right to hold consignments of pumps for which spare parts are not available.

Cement and fertiliser projects

The Minister of Communications has been granted the concession to establish and operate the cement factory planned for Abqaiq in the oil field area, and is negotiating with a German firm. The project to establish a fertiliser factory at Dammam has made little progress. Both these schemes will, it is hoped, use surplus gas from the oil fields.

ISRAEL

Calcination plant

Construction of a calcination plant for the treatment of phosphates is due to start shortly 70 km. south of Bersheeba. Equipment has been ordered from Germany.

AUSTRIA

Sulphuric acid project

The Wiener Chemikalien Handelsgesellschaft mbH. 'Chemia'—an affiliate of the Bayerwerken of Leverkusen—is building a sulphuric acid plant at Krems (Lower Austria) in co-operation with the firm of Kremschemie.

The output of the plant will be used in the manufacture of superphosphate fertilisers, and production will be great enough to cover domestic demand and permit a certain volume of exports. The firm has not disclosed production details, but on the basis of current domestic demand output is expected to be between 70,000 and 80,000 tons p.a. In 1953, Austria imported 72,000 tons of superphosphate worth 43.5 million schillings, mainly from Italy.

GERMANY

Petro-chemical industry

West German industrialists expect that the country's petro-chemical industry will make considerable progress in the next few years. Between 300,000 and 400,000 tons of refinery gases will be available annually as raw materials after the cracking plants now being built or already completed come into full operation, they say. The plants, part of large refinery installations, are concentrated in north Germany and the Ruhr.

The first important petro-chemical plant, now under construction, is the Rheinische Olefinwerke at Wesseling, near Cologne, set up jointly by the Shell Co. and the Badische Anilin & Sodafabriken. The plant will process refinery gases and, primarily, produce polyethylene, which will be sold under the name of *Lupolen*. It will also

turn out smaller quantities of ethyl benzole.

West German domestic requirements of polyethylene are estimated at between 10,000 and 14,000 tons p.a., a quantity which the Rheinische Olefinwerke is expected to be able to supply.

In the Upper Rhine valley petrochemicals are being produced from the natural gas from the oilfields near Darmstadt by the Farbwerke Hoechst. The gas is being supplied by pipeline to the Farbwerke plant, near Frankfurt, which uses it for the production of methyl chloride, chloroform, carbon tetrachloride and other products. At the beginning of next year gas from the same fields will also be supplied to the Badische Anilin and be used for the manufacture of chemical products.

Gas stored in caves

The Ruhrgas A.G., the major gas-supply undertaking in the Ruhr, is experimenting with a novel method of underground storage as a means of solving the recurrent problem of shortages in gas supplies during the winter. At Engelbostel, near Hannover, natural underground caves exist in which it is believed to be possible to store up to 200 million cu. m. of gas. Already 10 million cu. m. of gas have been dealt with in this way at an investment cost of DM5 million or DMo.5/cu.m., which is appreciably cheaper than normal methods of storage in high- or low-pressure chambers.

KENYA

Cement production

Plans have been announced for the establishment of a second cement works in Kenya, the new factory to be the enterprise of the East African Portland Cement Co. Ltd. It is expected that the new factory, with an output of 100,000 tons p.a., will be in production late in 1956, when the company's existing grindery plant in Nairobi will be closed down. The capital of the company is being increased to £1 million, and loans totalling £750,000 are being arranged privately as well. East African Portland Cement Co. Ltd. are associated with leading manufacturers in the United Kingdom.

HOLLAND

New cat cracker planned

The Bataafsche Petroleum Co. (Royal Dutch-Shell Group) have announced that a second catalytic cracking plant with a capacity of 5,000 tons/day is to be built at Pernis.

INDIA

Fertiliser production to be increased

India is to expand her nitrogenous fertiliser production by a further 250,000 tons p.a. by 1961. A special committee, the Fertiliser Production Committee, has been set up to co-ordinate the programme. It will advise on the location of plants, provision of technical personnel and will supply estimates of the capital required.

Indian fertiliser consumption is about 400,000 tons p.a., and present domestic output around 260,000 tons. The balance is imported, mainly from the U.S.

NORWAY

Another big aluminium plant planned

The Oslo firm A/S Elektrokemisk is planning to build an aluminium plant at Mosjöen in Nordland Province, north Norway. The plant will have a production of 20,000 tons p.a. of aluminium. Total Norwegian aluminium output last year was 56,000 tons, and should amount to about 100,000 tons next year when the new Sunndalsöra aluminium plant is in full production. The Mosjöen plant now planned will increase that amount by a further 20%.

It is not expected that the Mosjöen plant can be ready to start production until about 1957. The hydroelectric plant at Rössaga will have to be expanded to provide the additional 50,000 kw. of power required. The Rössaga power plant, which has been developed to provide power for the big new steel plant at Mo i Rana, will next year have an installed capacity of about 120,000 kw., but most of this will be needed by the steel plant, whilst the balance will be used for local domestic electricity supply. There is provision, however, for installing three more generating sets each to give 30,000 kw.

For A/S Elektrokemisk, aluminium production is a new departure. The company is noted chiefly for its manufacture of electric smelting furnaces.

BELGIUM

Cat cracker goes on stream

Head Wrightson Processes announce that, in conjunction with the Houdry Process Corporation and World Commerce Corporation of New York, work has been finished on a 3,600-bbl./day *Houdriflow* catalytic cracking unit, which has now gone on stream at the Antwerp (Belgium) refinery of Albatros S.A. Belge pour le Raffinage de Pétrole.

The new unit represents an important part of the current expansion and modernisation of the refinery. The cat cracker will produce high-octane petrol, which will be marketed domestically.

The Albatros refinery began operations in 1935; badly damaged during hostilities, it remained inactive throughout the war. The former installations were reconstructed in 1948.

Last year construction was begun on a new crude unit, feed preparation unit, cat cracker, gas recovery and stabilisation unit, plant for the polymerisation of light olefins produced in *Houdriflow* cracking operations and new facilities for treating straight-run and catalytic petrols.

The refinery is designed to process 10,000 bbl./day of Persian Gulf crude, and ultimate expansion to 15,000 bbl./day is planned. Petro-Carbon Ltd., Manchester, acted as consultants for Albatros.

CANADA

Sulphuric acid plant

Inland Chemicals (Canada) Ltd. has awarded a contract for construction of a $1-million sulphuric acid plant at Fort Saskatchewan, 25 miles east of Edmonton, Alberta. It will use southern Alberta sulphur to produce 100 tons/day of sulphuric acid.

British-Canadian citric acid project

To meet the increasing world demand for citric acid, a British and a Canadian chemical firm have announced the joint formation of a new company in Canada known as Sturge (Canada) Ltd. Manufacturing plant for the new company is now under construction at Valleyfield, Quebec, and is expected to be in production early next year.

The British firm, John & E. Sturge Ltd., of Birmingham and Selby, Yorkshire, were founded in 1823 and have experience of citric acid manufacture dating back nearly 130 years. In 1930 they were the first British firm to operate successfully a fermentation process for the production of citric acid from sugar. The Canadian partner in the new company is Merck & Co. Ltd., the chemical, pharmaceutical and antibiotic manufacturers.

PHILIPPINES

Carbide plant

A carbide and ferro-alloy plant which cost several million pesos was to be opened in October at Iligan City, Lanao, Manila. The plant, which is owned by the Maria Cristina Chemical Industries Inc., is designed to produce 30 tons/day of carbide. Since this is about twice as much as present Philippine consumption, it will be operated at half capacity for the first two or three years.

It is expected that the local steel industry will benefit from the products of the new plant. Up to now, local steel plants have been depending on imported ferro-alloys.

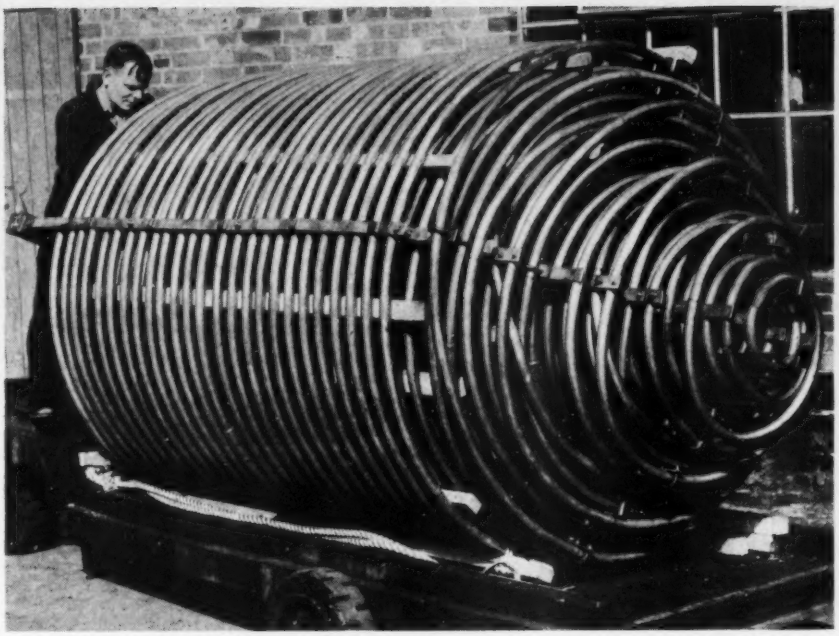
FINLAND

Nitrogen plant expansion

The Finnish Government proposes to double the output of the state nitrogen factory at Oulu in northern Finland. Present output is 16,000 tons of nitrogenous fertiliser p.a. The extension of this plant is expected to reduce the cost of the domestic fertiliser from 85 to 90 marks per kilo to 70 to 75 marks; imported fertiliser is now around 65 marks.

The consumption of nitrogen in Finland has risen from 10,000 tons in 1946 to 30,700 in 1953. This year consumption is expected to rise to 40,000 tons. Of the 16,000 tons produced at the Oulu factory, 1,000 tons are used for technical purposes. This means that only 40% of the country's total demand can be met.

The extension is expected to cost 2,400 million marks and to take two years to build.



Stainless-steel coil containing more than half a mile of tube for an overseas chemical installation. Built by Accles & Pollock Ltd., Oldbury, Birmingham, the unit weighs over 2 tons and consists of 10 coils, connected in pairs, and built one inside the other.

Finnish chemical equipment needs

As a result of the war and the abnormal situation during the post-war years there has been a shortage of machinery needed for modernising and expansion. A circular inquiry was sent to the chemical companies to reveal the present situation as to the amount of foreign currency required for necessary purchases, the extent to which machinery could be ordered from Finland's own machine industry, and as to the experience of chemical companies in regard to performance and deliveries of Finnish-made equipment. Depending on the nature of manufactured products, in some cases only 10%, in most cases 50 to 75% of new machinery were reported to be available in Finland. Some equipment, *e.g.* stainless-steel products and very specialised equipment, is being imported. The main difficulty with Finnish machine deliveries appears to be the long delivery time and the purchase tax which often increases the price considerably. This subject is discussed by Y. Talvitite in *Tek. Kem. Aik.*, **11** (14), 483-484.

UNITED STATES

Synthetic rubber project

A new plant to manufacture neoprene synthetic rubber will be built in Montague, Michigan, by E. I. du Pont de Nemours & Co. Work is scheduled to start next spring, with completion expected in late 1956. The plant will be built on a 1,000-acre site adjoining a site of Hooker Electrochemical Co. Hooker will manufacture hydrogen chloride, delivering it by pipeline to the du Pont plant as a raw material for the neoprene.

Another plant, to be built by Union Carbide & Carbon Corp., will generate acetylene, the other major raw material for neoprene. This will also be piped into the du Pont plant.

Potash project

Negotiations between the Freeport Sulphur Co. and Pittsburgh Consolidation Coal Co. are under way for a joint $16-million potash project. The companies would have a mine and refinery about 30 miles east of Carlsbad, New Mexico. The proposed plant would produce 240,000 tons p.a. of potassium oxide and commercial potash, and require two years to build.

Anhydrous ammonia project

The Sun Oil Co. will enter a new branch of the petro-chemical field with the construction of a $9-million anhydrous ammonia plant at its Marcus Hook, Pennsylvania, refinery. The new plant, to be completed late in 1955, will have a daily capacity of 300 tons.

Another Sun Oil development is the bringing on stream of a new process, developed by its research department, for processing lubricating oils.

Venezuelan sulphur deposits

The U.S.-owned Venezuelan Sulphur Corporation, set up to exploit sulphur reserves in Venezuela, is planning to build a plant to process about 100,000 tons p.a. of sulphur and hopes to go into production in about a year. It is planned to sell the sulphur mainly in Latin America. Some of it will go to new industries in Venezuela and the remainder to Europe.

A refining method devised by the Krupp interests of Germany may be used. The U.S. engineering firm of Arthur D. Little, of Cambridge, Mass., is finishing a survey which will finally determine whether this or another process will be adopted. It is understood that Krupps have guaranteed the firm a processing cost of $13/ton.

Fertiliser projects

Jefferson Lake Sulphur Co. is planning to enter the chemical fertiliser business with the construction of sulphuric acid and triple superphosphate plants in south-eastern Idaho. The area contains large phosphate rock beds.

New petro-chemical company

United Gas Corporation and its parent, Electric Bond & Share Co., are preparing to enter the petro-chemical field with a new $26,800,000 firm, Gulf Chemical Co. Under an application filed with the Securities and Exchange Commission asking for permission to purchase securities in the new company, Gulf Chemical would build a $22,920,000 plant near Pensacola, Florida, and would require working capital of $3,880,000.

The new company would make and sell industrial and agriculture chemicals; initially the new plant is expected to have a daily capacity of 200 tons of anhydrous ammonia and 40 tons of polyvinyl chloride.

United Gas and Electric Bond, according to the S.E.C. filing, would equally control Gulf Chemical, each putting up $13,400,000. United Gas is at present part of the Electric Bond & Share holding company system, but under a plan approved by the S.E.C. this affiliation is to be severed.

Pressure hydrogasification of oils

Results of a laboratory study of the effects of pressure and feed hydrogen in high-B.Th.U. oil gas production are presented in ' Production of Natural Gas Substitutes by Pressure Hydrogasification of Oils,' an Institute of Gas Technology, Chicago, interim report by H. R. Linden, J. J. Guyer and E. S. Pettyjohn.

Three typical gas-making oils—diesel oil, reduced crude and Bunker C—were employed in the tests, which were carried out at gasification pressures of 1 to 5 atm., cracking temperatures of 1,350 to 1,550°F., residence times of 2.5 to 10.5 sec. and hydrogen-oil feed ratios of 0 to 90 S.C.F./gal. Data on the substitutability of the gases for high-methane natural gas are reported and burner test results are related to gas composition. The combustion tests were conducted at approximately rated burner heat inputs using the five critical appliance burners employed in previous studies of oil gas-natural gas substitutability. These data, with the Institute's previously published studies of high-B.Th.U. oil gas production, provide a basis for application of the novel pressure hydrogasification process to the design of plants for the production of complete natural gas substitutes.

MEETINGS

Institution of Chemical Engineers

December 14. 'The Drying of Wheat Grain,' by Prof. Ewan McEwan *et al.* and P. E. Gishler, 5.30 p.m., Geological Society, Burlington House, London, W.1. Joint meeting with the Chemical Engineering Group, Society of Chemical Industry, and the Institution of British Agricultural Engineers.

December 16. 'The Adiabatic Absorption of Hydrogen Chloride,' by T. A. Kantyka and H. R. Hinchlieff, 7 p.m., the University, Leeds.

Chemical Society

December 9. 'Recent Researches in Crystallography,' by Prof. Kathleen Lonsdale, 7.30 p.m., North British Station Hotel, Edinburgh. Joint meeting with the R.I.C. and the S.C.I.

Institution of Mechanical Engineers

December 10. 'Cylindrical Pressure Vessels: Stress Systems in Plain Cylindrical Shells and in Plain and Pierced Drumheads,' by W. B. Carlson and J. D. McKean, 5.30 p.m., 1 Birdcage Walk, London, S.W.1.

Incorporated Plant Engineers

December 14. 'Vacuum and Air in Industry,' Sturtevant Engineering Co. Ltd., 7.15 p.m., Mackworth Hotel, Swansea.

December 15. 'Steam for Process,' by L. G. Northcroft, 7 p.m., Scottish Building Centre, 425-427 Sauchiehall Street, Glasgow.

December 15. 'Steam-main Design and Modern Development in the Field of Gamma-Ray Examination of Pressure Welds,' by E. Marson and H. Webborn, 7 p.m., Bull Hotel, Rochester, Kent.

Junior Institution of Engineers

December 31. Film, 'The Manufacture of Portland Cement,' 7 p.m., Pepys House, 14 Rochester Row, London, S.W.1.

Institute of Metals

December 16. 'Protective Atmospheres for the Heat Treatment of Steels,' by Ivor Jenkins, 7 p.m., Liverpool Engineering Society, 9 The Temple, Dale Street, Liverpool.

January 4. 'Titanium,' by Major P. Litherland Teed, 7 p.m., Ballroom, Cadena Cafe, Cornmarket Street, Oxford.

Institution of the Rubber Industry

December 13. 'Synthetic Fibres in the Rubber Industry,' by D. Bramley, 7.30 p.m., College of Technology, Cardiff.

December 14. 'Compounding of Vinyl Polymers,' by S. Mottram, 5.30 p.m.; 'Polymer-modified Natural Rubber,' by Dr. F. M. Merrett and R. I. Wood, 7 p.m.; Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1.

Institute of Fuel

December 9. 'Note on the "Optimum Degree" of Coal Washing,' by J. K. Matthews, 5.30 p.m., Institution of Civil Engineers, Great George Street, London, S.W.1.

January 10. 'Carbonisation of Blends of Coal to Produce Metallurgical Coke,' by H. Bardgett, 6.30 p.m., Chemistry Lecture Theatre, King's College, Newcastle-upon-Tyne.

Recent publications

(*See also page* 396)

Mining and crushing equipment. The products and manufacturing methods of British Jeffrey-Diamond Ltd. are described in a handsomely produced 30-page pamphlet. The first two pages deal with the history and development of the company and its associates from 1879, when William Garforth, who had been experimenting for several years with coal cutters, founded the Diamond Coal Cutter Co., to the formation of Galion (Great Britain) Ltd. little more than two years ago for the manufacture of motor graders. The British Jeffrey-Diamond range of mining machinery is then described. It includes coal cutters for straightforward application, or cutting specific portions of a seam. The company's pulverising equipment is also described. Finally, manufacturing operations at the company's works are dealt with.

Fluid-fluid extraction. *Flüssig-Flüssig—Extraktion* is the title of a new number that has just been issued in the 'Dechema - Erfahrungsaustausch' series (57 pp.). As the extraction of fluids is of increasing importance in chemical engineering, this handy guide will be welcomed by every chemist and engineer who has to plan, estimate or operate in this field. A short survey of extraction processes is followed by detailed descriptions of individual extraction units. A further section contains all relevant basic calculations, illustrated by examples. A reference to current literature on the subject and a copious index close the volume. As is the case with all numbers appearing in the 'Dechema-Erfahrungsaustausch' series, this pamphlet is issued in manuscript form and can only be obtained from the Deutsche Gesellschaft für chemisches Apparatewesen, price 22.80 marks.

Kent oil refinery. The building of Anglo-Iranian's 4-million-tons/year oil refinery in Kent on the marshlands of the Isle of Grain is told in a new booklet, with the aid of many photographs, maps and charts, a large number of them in colour. This booklet is written in non-technical language and is intended primarily for the ordinary reader. It is a handsome tribute to the men who built this great refinery in the face of great difficulties.

Another booklet, giving a technical description of the Kent oil refinery, has also been produced. In this, descriptions are given of the distillation process and the catalytic cracker with the various by-products produced, the SO_2 extraction plant, the platformer, the treatment and sweetening plants, followed by a description of the lubricating oil refinery where 130,000 tons/year of lubricating oil will be manufactured. The technical description covers the whole refinery, even going into such details as the purifying of effluents before disposal into the Medway and the removal of oil wastes from tankers to prevent contamination of neighbouring waters.

New British Standards

Chlorobenzene (B.S. 2533: 1954, 2s.); **dibutyl sebacate** (B.S. 2535: 1954, 2s.); **di-2-ethylhexyl sebacate** (B.S. 2536: 1954, 2s. 6d.). These three new standards bring the total number of British Standards for solvents and allied products to 36. Limits are specified for the physical properties of the materials and for impurities likely to be present, and full details of the method of analysis are given.

CHEMICAL & PROCESS ENGINEERING

ENQUIRY BUREAU

Stratford House, 9 Eden Street, London, N.W.1

Readers requiring names of suppliers of raw materials, machinery or finished products should complete this form and attach it to their business note-heading. Please state approximate quantities required.

We wish to know names and addresses of suppliers of the following:

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For office use only. No. Date

Chemical & Process Engineering

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(Including the March, April and May 1954 issues of **Corrosion Technology,** which was published for those three months as a supplement to CHEMICAL & PROCESS ENGINEERING and appeared subsequently as a separate journal. Supplement page numbers are indexed in **bold type**)

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